

THE BRITISH SOCIETY FOR THE PROMOTION
OF VEGETABLE RESEARCH

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Ninth
Annual Report
1958

(OCT. 1957 - SEPT. 1958)

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NATIONAL VEGETABLE RESEARCH
STATION

WELLESBOURNE - - WARWICK

Telephone : Wellesbourne 382 (3 lines)

1959



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THE CONSTITUTION OF THE NATIONAL VEGETABLE RESEARCH STATION

The National Vegetable Research Station (N.V.R.S.) at Wellesbourne, Warwickshire, and its Sub-Station at Paglesham, Essex, were established under a Governing Body incorporated on 28th September 1949, as a company limited by guarantee, not having a share capital, and having the title 'The British Society for the Promotion of Vegetable Research', with its registered office at Wellesbourne.

The members of the Governing Body, twenty-three in number, include nominees of the two Agricultural Departments of Great Britain, of the Department of Scientific and Industrial Research, of various learned societies, universities and institutions concerned with horticulture, of vegetable producers (through the National Farmers' Unions of the two countries and the National Allotments and Gardens Society) and of trade interests.

The properties at Wellesbourne and Paglesham are leased to the Society by the Agricultural Research Council (A.R.C.) and by the Ministry of Agriculture, Fisheries and Food, respectively. Until 31st March 1956, the Society depended for its funds on grants from this Ministry who were advised by the A.R.C. regarding research work and staff. On 1st April 1956, the grant-aiding functions of the Ministry were transferred to the A.R.C. If the Society establishes stations or conducts work in Scotland, grants will be receivable from the Scottish Agricultural Advisory Council who will be advised by the A.R.C.

GOVERNING MEMBERS OF THE SOCIETY

Appointed by the Minister of Agriculture, Fisheries and Food :

- Professor K. MATHER, C.B.E., D.Sc., F.R.S., Department of Genetics,
The University, Edgbaston, Birmingham, 15.
- W. J. F. SOPER, Esq., J.P., New Hall Farm, Harlow, Essex.
- Professor P. T. THOMAS, B.Sc., Ph.D., Department of Agricultural Botany,
The Institute of Rural Science, University College of Wales, Penglais, Aberystwyth.
- Professor C. W. WARDLAW, Ph.D., D.Sc., F.R.S.E., F.L.S., Department of Botany,
The University, Manchester, 13.

Appointed by the Secretary of State for Scotland :

- R. L. SCARLETT, Esq., C.B.E., C.D.A., V.M.H., Sweethope, Musselburgh, Midlothian.
(Until 27/9/1958).
- Principal M. A. H. TINCKER, M.A., D.Sc., F.L.S., The North of Scotland College of
Agriculture, 41½ Union Street, Aberdeen. (From 28/9/1958).

Appointed by the Department of Scientific and Industrial Research :

- R. G. TOMKINS, Esq., M.A., Ph.D., Ditton Laboratory, Larkfield, Maidstone, Kent.

Appointed by the University of London :

- Professor J. W. MUNRO, C.B.E., M.A., D.Sc., Froggnall Cottage, Sunninghill, Berks.
(Until 5/6/1958).
- Professor H. W. MILES, D.Sc., Wye College, (University of London), Ashford, Kent.
(From 28/9/1958).

Appointed by the University of Reading :

- Professor O. V. S. HEATH, D.Sc., Department of Horticulture, The University, Reading,
Berks. (From 6/2/1958).

Appointed by the University of Cambridge :

- J. BARKER, Esq., M.A., Ph.D., F.R.S., The Botany School, Downing Street, Cambridge.

Appointed by the University of Bristol :

- Professor T. WALLACE, C.B.E., M.C., D.Sc., F.R.I.C., V.M.H., F.R.S., 'Redwings', Old
Church Road, Nailsea, Somerset. (Until 27/9/1958).
- Professor H. G. H. KEARNS, O.B.E., B.Sc., Ph.D., Dip. Agric., University of Bristol,
Department of Agriculture and Horticulture, Research Station, Long Ashton,
Bristol. (From 28/9/1958).

Appointed by the University of Edinburgh :

- ALEXANDER NELSON, Esq., Ph.D., D.Sc., F.R.S.E.,
University Department of Botany, at Royal Botanic Garden, Edinburgh, 3.

Appointed by the Royal Society :

- Professor W. BROWN, M.A., D.Sc., F.R.S., The Bush, Haddenham, Aylesbury, Bucks.

Appointed by the John Innes Horticultural Institution :

- K. S. DODDS, Esq., Ph.D., D.Sc., Bayfordbury, Herts.

Appointed by the National Farmers' Union :

- F. M. BARDSLEY, Esq., Low Mill Farm, East Ayton, Scarborough, Yorks.
(From 28/9/1958).
- A. H. BOARDMAN, Esq., A.M.I.B.A.E., Lunts Farm, Paglesham, Rochford, Essex.
(Until 27/9/1958).
- A. A. CLUCAS, Esq., 'Rockmeads', Halland, Near Lewes, Sussex. (Until 20/2/1958).
- R. FORD, Esq., Began Farm, St. Mellons, Cardiff, Glamorgan. (From 28/9/1958).
- G. G. HOLE, Esq., Pakyns, Hurstpierpoint, Sussex.
- J. LAITY, Esq., Polkinghorne, Gwinear, Hayle, Cornwall.
- W. F. SWIFT, Esq., Avon Cottage, Fladbury, Pershore, Worcs.

- Entomology :** D. W. WRIGHT, M.A. (Cantab.).*
 J. A. DUNN, M.Sc. (Dunelm), Ph.D. (Birm.).
 G. A. WHEATLEY, B.Sc. (Dunelm).
 R. D. HUGHES, B.Sc., Ph.D. (Lond.).
 Mrs. D. D. SALTER, B.Sc. (Dunelm).
 J. S. BUXTON, B.Sc. Hort. (Nott.). (Resigned 31/12/1957)
 J. A. HARDMAN, B.Sc. Hort. (Nott.).
 Miss J. WORRALL, B.Sc. (Lond.). (Appointed 29/9/1958)
Assistants : H. I. SMITH.
 Miss G. BUBB.
 Miss C. LOWE. (Appointed 8/9/1958)
 Miss J. MARCH.
 Miss A. SARGENT. (Resigned 30/4/1958)
 Mrs. C. R. SLAUGHTER.
- Pathology :** W. G. KEYWORTH, B.Sc., Ph.D. (Lond.), A.R.C.S., D.I.C.*
 A. G. CHANNON, B.Sc. (Aberdeen).
 R. B. MAUDE, B.Sc. (Dublin), M.Sc. (Nott.).
 J. A. TOMLINSON, B.Sc., Ph.D. (Birm.).
 Miss R. P. GOODCHILD, B.Sc. (Leeds). (Appointed 22/9/1958)
 Miss J. S. HOWELL, B.Sc. (Birm.).
 Miss B. R. SMITH, B.Sc. Hort. (Lond.).
 M. J. W. WEBB, B.Sc. Hort. (Nott.).
Assistants : Miss J. DOW. (Appointed 1/12/1957)
 Miss M. P. INSALL.
 Mrs. P. A. KNIBB (née DADLEY).
 Miss J. TAYLOR.
 Miss A. P. WARD, N.D.D.H. (Resigned 30/11/1957)
- Weeds :** H. A. ROBERTS, B.Sc. (Manc.).
 J. M. WAY, B.Sc. Hort., M.Sc. (Lond.).
 (Working under A.R.C. grant from 1/5/1958)
 Miss S. M. S. HIRD, B.Sc. (Lond.), M.Sc. (Saskatchewan).
 (Appointed 9/6/1958)
 Miss M. E. SMART, B.Sc. (Lond.).
Assistants : Mrs. A. H. T. GEORGE.
 Miss U. W. LAURENCE.
 B. J. WILSON. (Appointed 22/9/1958)
- Statistics :** J. A. NELDER, M.A. (Cantab.).
Assistants : Miss S. DOWLER. (Resigned 8/3/1958)
 Miss A. DRAYCOTT. (Appointed 10/3/1958)
 Miss A. MEADUS. (Resigned 30/6/1958)
 Miss H. E. RUSSELL.
 Miss A. R. TUFFIN. (Appointed 25/8/1958)
- Librarian :** Miss B. M. MOORE, N.D.D.H.
- Photographer :** Miss J. KULLMAN. (Resigned 31/7/1958)
- Farm :** *Manager :* T. J. NORWOOD.
Foremen—Wellesbourne : I. F. REYNOLDS. (Resigned 26/9/1958)
Paglesham : D. T. McVITTIE.
- Administration :** *Secretary :* J. J. HOLLIST, B.Com., LL.B (Lond.), A.A.C.C.A., A.I.B.
 (Resigned 28/2/1958)
 G. LESSON, B.Sc. (Econ.), A.C.I.S. (Appointed 2/6/1958)
Accounts Assistant : D. A. BARTLETT.
Administrative Assistant : L. C. FITZGERALD.
Director's Secretary : Miss E. B. FORRESTER. (Resigned 26/9/1958)
 Mrs. J. M. FAULKNER. (From 1/10/1958)
Clerical Officer : Mrs. J. BLOUNT.
Assistants : Miss G. E. A. CLACK.
 Miss S. CLARKE. (Appointed 1/4/1958)
 Miss J. SHAW. (Appointed 21/7/1958)
 Miss W. STYLES. (Resigned 31/1/1958)
 Miss S. M. L. McDONAUGH.

*Recognised lecturer of the University of Birmingham.

REPORT OF THE DIRECTOR

DEVELOPMENT

By the end of January 1959 work on the main block of laboratories and offices was nearing completion. Work was in progress on interior fixed fittings such as laboratory benches and shelves, on internal painting, and on laying floor coverings; electric light fittings had yet to be installed. An isolated store for chemicals, and an electricity transformer and meter house were also built during the year.

Work was completed on the 100 ft. by 30 ft. glasshouse containing twenty compartments for plant breeding work, and the brick walls, floors and drainage have been completed for another glasshouse of the same dimensions.

At Paglesham, a steel and asbestos multi-purpose barn 75 ft. by 45 ft. was erected in October 1958.

STAFF

Appointments

On 1st May 1958 Mr. J. M. Way was transferred from the Pathology Section to the Weeds Section and began investigations on herbicidal spray drift damage under a special grant from the A.R.C.

Mr. D. H. Drew was appointed as a Scientific Officer in the Irrigation Section on 28th July in succession to Dr. G. Stanhill.

Mr. T. J. Cleaver, who was previously on the staff of the Grassland Research Institute at Hurley, was appointed as an Assistant Experimental Officer in the Chemistry Section on 1st February 1958.

Miss S. M. S. Hird joined the staff as an Assistant Experimental Officer in the Weeds Section on 9th June. She had just completed a period of post-graduate study on plant ecology under a scholarship at the University of Saskatchewan, Saskatoon, Canada.

Miss P. M. Lievesley was appointed as an Assistant Experimental Officer in succession to Dr. J. Clare Hughes in the Chemistry Section on 11th August.

Miss E. M. Slade joined the staff as an Assistant Experimental Officer in the Plant Breeding Section on 8th September.

Miss R. P. Goodchild was appointed as an Assistant Experimental Officer in the Pathology Section on 22nd September.

Miss J. Worrall joined the staff as an Assistant Experimental Officer in the Entomology Section on 29th September.

Mr. G. Lesson was appointed as Secretary to the Society and the Station on 2nd June 1958 in succession to Mr. Hollist. Mr. Lesson was previously employed as Secretary to the Manchester District Nursing Institution.

The following 12 Scientific Assistants were appointed during the year, 11 of whom replaced those who had resigned:—

Miss J. Dow, Pathology	Mr. G. M. R. Trueman, Irrigation
Miss A. Draycott, Statistics	Miss S. J. Hemmings, Physiology
Mr. M. J. Clayton, Chemistry	Miss C. Lowe, Entomology
Miss D. E. Allen, Plant Breeding	Mr. B. J. Wilson, Weeds
Mr. R. H. Jones, Plant Breeding	Miss S. Smith, Physiology
Temporary appointment.	Miss C. J. Snell, Physiology
Miss A. Tuffin, Statistics	

Four University students were employed during the summer to assist in the research sections.

Miss S. Clarke was appointed as a Shorthand-Typist on 1st April, and Miss J. Shaw was appointed as a Clerical Assistant on 21st July 1958.

Resignations

Mr. J. S. Buxton resigned on 31st December 1957 to take up a post with the National Institute of Agricultural Engineering at Silsoe.

Mr. J. J. Hollist resigned from his post as Secretary on 28th February.

Dr. J. Clare Hughes resigned on 31st May.

On 31st May Dr. G. Stanhill resigned to take up a post at the Agricultural Research Station, Department of Irrigation and Soil Technology, Rehovot, Israel.

Miss E. B. Forrester left the Station on 26th September, to take up another post.

Miss J. K. Kullman resigned her post as Photographer on 31st July.

11 Scientific Assistants resigned during the year ; Miss A. P. Ward and Miss W. Horn left to be married ; Miss S. Dowler, Miss A. Sargent and Mr. A. S. Morgans took up positions elsewhere ; and Miss P. A. Hodnett, Miss P. Hurley and Miss B.A. Freeman resigned on gaining entrance to Universities.

Miss W. Styles resigned on 31st January.

Mr. I. F. Reynolds resigned from his post as Farm Foreman on 26th September.

Higher degree

We congratulate Mr. J. A. Dunn on having been awarded the degree of Ph.D. by the University of Birmingham. His thesis, entitled 'The biology, bionomics and control of lettuce root aphid', was based on his work at Wellesbourne. We are pleased to record also that Mr. Dunn is the first member of the staff to have been awarded a higher degree by Birmingham University under the arrangement made between the University and the Station in 1956.

Mr. B. Mitchell, who was seconded by the University of Birmingham in October 1956 to carry out research for a higher degree under an A.R.C. Research Studentship, continued his work in the Entomology Section.

Worker from overseas

Arrangements were made with the Department of Horticulture, University of Reading, for Mr. R. A. Prieto-Ruiz of Venezuela to carry out research at the N.V.R.S. for a period of up to one year, from November 1957, as part of his work for the degree of M.Sc.

Conferences in the U.K. and abroad

A number of conferences were attended during the year by members of the research staff. In January 1958 Mr. Roberts and Mr. Winter attended the N.A.A.S. Regional Horticultural Officers' Conference at Pershore, at which they both read papers. In February, Dr. Haworth was present at a Nitrogen Meeting of the Society of Chemical Industry, and Dr. Spragg and Dr. Clare Hughes attended the Biochemical Society's Symposium on Glutathione, in London. Mr. Roberts also read a paper on 'Chemical weed control' at the N.A.A.S. Regional Staff Conference in Torquay. In March, Mr. Wright read a paper on 'Recent developments in the control of carrot fly' at a Conference of Advisory Entomologists held in London ; Mr. Roberts and Dr. Bleasdale were present in Oxford at the British Weed Control Council Symposium on 'The evaluation of herbicides' ; and Mr. Winter read a paper on 'Irrigation of vegetables' at the N.A.A.S. County Agricultural Officers' Conference in Cirencester. In April, Dr. Spragg took part in a meeting of the Phenolics Group of the Society of Chemical Industry which was held in Oxford and, during the same month, Mr. Wright and Mr. Wheatley attended the A.R.C. Conference on Insecticides and Fungicides at Rothamsted. Dr. Philp, Dr. Haigh, Mr. Holland, Dr. Johnson, Mr. Nelder and Mr. Watts attended the A.R.C. Conference of Plant Breeders held in Aberystwyth during July. In the same month, Mr. Wright was present in Belfast at the Summer Conference of Advisory Entomologists, and Dr. Hughes read a paper entitled 'Sampling aggregated populations' at an International Colloquium on Methods in Soil Zoology

held at Rothamsted. The Summer Meeting of the British Society of Soil Science, held in Bangor, was attended by Dr. Haworth. At a meeting in London of the Institute of Biology, held in September, Dr. Bleasdale read a paper on 'The effects of air pollution on plant growth'.

Grants were kindly provided by the A.R.C. to enable members of staff to attend the following conferences. Dr. Haigh and Dr. Salter took part in the 15th International Horticultural Congress, held in Nice during April, when they read papers on 'Cultural value of varieties and breeding material, and its evaluation' and 'Some factors to be taken into account in planning the field irrigation of vegetables', respectively. Dr. Johnson attended the 10th International Congress of Genetics in Montreal during August and, later in that month, Mr. Nelder attended the 4th International Biometric Conference in Ottawa where he spoke on 'The estimation of variance components in certain types of experiments in quantitative genetics'. In September, Dr. Spragg read a paper on 'The effect of ionizing radiation on sulphhydryl groups of pea seedlings' at the Biochemistry Congress held in Vienna.

Award of a Fellowship

Dr. J. A. Tomlinson was awarded a W.K. Kellogg Foundation Fellowship for six months for research and study in the Plant Pathology Department at the University of Wisconsin, U.S.A., from March–August 1958. His research programme, however, was extended for two extra months, September and October, through the kindness of the University of Wisconsin in providing funds. He carried out research on the purification, properties, electron microscopy and serology of cucumber mosaic virus, under the direction of Professor J. C. Walker, Professor of Plant Pathology at the University. He also visited research institutes in the Western, Mid-Western and Eastern States and attended the Symposia at the Golden Anniversary Meeting of the American Phytopathological Society at the University of Indiana, Bloomington, during August. While in the U.S.A. he gave lectures at the University of Wisconsin, Madison and the University of California, Davis. The visit was most profitable to Dr. Tomlinson and to this Station and appreciation is expressed to the W.K. Kellogg Foundation for providing the Fellowship, and to the Agricultural Research Council for providing the voyage expenses to and from New York. Thanks are due to Professor J. C. Walker and Professor R. J. Shepherd for all they did to make Dr. Tomlinson's visit so successful. Thanks are due also to Professor R. G. Grogan of the University of California, and to members of the staffs of the research institutes who gave of their time to show Dr. Tomlinson their work and discuss problems with him.

Lectures

Over twenty lectures were given on the work of the Station to growers in different parts of the country by various members of the staff during the year.

In October 1957, for the second year in succession, Mr. Wright gave two lectures to the final honours students of the Zoology Department of Birmingham University on 'The biology, ecology and control of certain insects of economic importance'.

During May 1958, Dr. Philp gave a series of three lectures to the Genetics Department of Birmingham University on 'Genetics as applied in plant breeding'.

Sporting and social activities

A fancy dress party on 22nd November 1957 was the first social event of the year when 60 members of staff arrived, in disguise, to enjoy the evening's entertainment in the canteen. Mr. and Mrs. W. F. Swift kindly acted as judges and presented prizes to the winners in the fancy dress parade. Once again an excellent meal was prepared for the staff Christmas lunch on 17th December and was greatly appreciated by the 89 people who were able to attend. For this, our grateful thanks go to the Canteen Committee and to the kitchen staff. The Christmas–New Year party was held in the canteen on 10th January 1958. Members of staff and their friends, numbering 110, thoroughly enjoyed this very successful party. Another new departure in our social

events proved to be most popular when 70 people visited the Coventry theatres on 16th June. On 9th August a Station Sports and Flower Show, followed by a social, was enthusiastically supported by the staff and their families. Mrs. H. Whetter was kind enough to judge the best exhibits from a large selection of floral arrangements, handicrafts, cookery and preserves and, later in the afternoon, Mrs. J. C. Haigh presented the prizes. The sports side of this function included items for the enjoyment of adults and children. One of the major adult events, a farm staff versus research staff tug-of-war, was won by the farm staff. Dancing took place in the canteen during the evening to complete the day's programme. For this, and the other three very successful social occasions during the year, we thank the Sports and Social Committee, Mrs. Knibb, Miss Platt, Miss Smith (Chairman), Mr. Faulkner (Treasurer), Mr. Maude (Secretary) and Mr. Norwood.

The Station's cricket team played 13 matches, five of which they won, four were lost, three were drawn, and one resulted in a tie. The hockey team won one and lost four of their matches. The lawn tennis team played seven matches against local clubs of which they won three. The Stamp Club held three formal meetings during the year, at one of which the Club Secretary, Dr. Haigh, gave a talk on stamp collecting.

It was our pleasure to have the Long Ashton Research Station cricket and tennis teams at Wellesbourne on 28th June and, although the N.V.R.S. teams were both defeated, the days' sport once again proved to be a most outstanding and enjoyable occasion.

RESEARCH

Plant Breeding

Further trials of hybrids between selected inbred lines of the Cambridge varieties of Brussels sprouts have again shown that some of the hybrids gave yields of marketable sprouts which exceeded those given by the Cambridge varieties themselves by over 50 per cent. The progeny testing technique also was tested further and the results confirmed that strains produced by this method can give improved yields of marketable sprouts but of a lower order than that given by hybrids between inbred lines.

Good progress has been made in breeding work with the object of producing a winter hardy, early maturing, culinary pea of good quality. Crosses had been made between the extremely winter hardy, round-seeded but poor quality Austrian winter maple pea and non-winter hardy, wrinkled-seeded culinary varieties of good quality. Some F_2 plants grown from wrinkled seed survived the winter of 1957-58 and it is hoped that they will retain the good quality associated with this seed character. All plants of the wrinkled-seeded parent varieties on the other hand were killed.

Plants were selected out of the varieties of spring cabbage which did best in a series of trials at Wellesbourne, and they were used for the breeding of an improved dual purpose variety, i.e., suitable both as greens and hearted cabbage. Selfing, and crossing within and between varieties was carried out and certain of the progenies grown during 1957-58 showed distinct improvement in the required directions. This work is being continued.

Three generations of inbreeding have now been carried out with the earliest summer cauliflower variety Cambridge No. 5 in an attempt to improve its curd quality. The results so far indicate that in a few of the inbred lines some improvement in quality has been achieved. With the same object in view, a breeding programme is in progress involving crosses between Cambridge No. 5 and a Dutch variety No. 35 of superior curd quality but a week later in maturing.

Male asparagus plants are preferred to female plants for cropping purposes but asparagus seed normally produces males and females in equal proportions. Success has been achieved, however, in producing 'super male' plants which, when crossed on to normal females, give all-male progenies.

In the course of work by the Pathology Section on the *Didymella* stem rot disease of outdoor tomatoes, a strain of *Lycopersicon hirsutum* was found to be highly resistant

to stem and root infection by *Didymella*. F_1 hybrids have been produced between this strain and a cultivated tomato variety and have been found to be as resistant as the *hirsutum* parent. A breeding programme is now in progress with the object of transferring to varieties of tomatoes the resistance of *hirsutum* but not its other undesirable characteristics.

Some work has been done on self-blanching celery as a preliminary to breeding for improved quality.

The annual supply of nucleus stock seed of those Cambridge varieties which are on the market was again provided to the N.I.A.B. for the production of stock seed. The stock seed will be supplied to recognised seed growers for the production of commercial seed under the scheme described in the Annual Report for 1952.

Chemistry

The three long-term field experiments have now completed the second year of the second cycle of the three year crop rotation of vegetables. The effects of the various treatments on crop production in 1958 agreed in general with those found in previous years. FYM again produced the greatest effect on yield and it was found that leeks were more sensitive than brassicas to phosphate and potash deficiency conditions in the soil. Wellesbourne results, which showed that one early top dressing of inorganic nitrogenous fertiliser had an equal or better effect on the yield of spring cabbage than the same total amount applied in three or four separate dressings, were confirmed by four experiments in the Evesham valley. For the first time in the cultivation experiment, peas responded better to shallow primary cultivation than to deep cultivation, whereas none of the primary cultivation treatments had previously differed from the others in its effect on yield of pods; and both Brussels sprouts and leeks, for the second time, gave as good yields with shallow as with deep cultivation.

The yield results of these long-term experiments are of practical value but they are of additional importance in that they show that the treatments have now produced a set of soils which differ fairly consistently in their effects on the growth of vegetable crops. These soils, therefore, provide suitable material for the study of the chemical, physical, biological and ecological changes which take place in raising soil fertility to the high level required for vegetable production. They also provide plant material for the study of their different chemical and physiological effects on vegetable crops.

A field experiment in 1957 with runner beans showed that FYM itself or combined with fertiliser had an outstandingly superior effect on yield as compared with either peat or fertiliser or a combination of both. As expected, the residual effects of these treatments on yield were reduced in 1958; FYM with fertilisers again gave the highest yield but the residual effect of FYM was equalled by that of peat with fertiliser.

Chemical investigations have shown that changes in the amounts of sugars and organic phosphates in the roots of red beet were associated with bolting, and have indicated that similar changes occurred in roots prior to flowering in the normal way. Some work has also been done on the biochemistry of the germination of pea seeds.

Plant Physiology

Studies have been continued on the competition between weeds and vegetable crops, and on the effects of different spatial arrangements of vegetable plants on yield. Growth studies on carrots were also continued.

The effects of different sowing rates and sowing dates on the performance of the varieties of pickling onions previously found to have satisfactory bulb characteristics for the pickling trade, were tested in 1958. Sowing rates of 20 or 30 lb. per acre gave better results than the rate of 40 lb. per acre, and yields from a sowing in March did not differ from those obtained from a sowing in April.

A trial of onions grown in 1958 from onion sets of different varieties and sizes which had been stored over winter at 20°C. and in an unheated store, showed that set size and also storage conditions affected the percentage of bolting and the yield, and that the varieties differed in yield performance, in proneness to bolting, and in the keeping properties of the bulbs.

Variability in yield performance of onions is often associated with variability in the germination of the seed and the results of an experiment have indicated that different sites at which the bulbs have been seeded have different effects on the germination capacity of the seed produced.

Tests of gibberellic acid for the induction of flowering indicated that it was likely to be of limited value in plant breeding work with vegetables. It was found also that gibberellic acid treatment of rhubarb crowns could break their dormancy but the subsequent growth when 'forced' was inferior to that of crowns whose dormancy had been broken by natural cold conditions.

A late-flowering selection of green watercress which can be cropped over an extended season has given promising results in trials.

Irrigation

The after effect of keeping young plants of early summer cauliflower, variety Finney's 110, dry as opposed to keeping them moist while being wintered in pots in frames was shown to be the production of smaller and earlier curds. Growth studies on early summer cauliflower were continued.

It has been found that summer lettuce gave a good response when it was kept well supplied with water from the time of planting through to harvest; a soil moisture deficit of $\frac{1}{2}$ -inch or more adversely affected the crop yield. The results of one experiment suggested that application of water as a mist gave a better crop of lettuce than when the same quantity was applied as a spray.

The irrigation experiments, using oscillated spraylines and with no protection from rain, were continued in co-operation with the N.A.A.S. Experimental Horticulture Stations. In general, the irrigation treatments at $\frac{1}{2}$ -inch and $\frac{3}{4}$ -inch soil moisture deficits depressed crop yields in 1958, presumably because the soil was often saturated by rain following irrigation.

Investigations were begun with runner beans to determine the cause of flowers failing to set pods, and of pod shedding. Irrigation itself or together with spraying of the flowers failed to affect the number or weight of pods harvested but 1958 was a wet season and it is hoped to repeat the experiment in a drier year. Experiments indicated that insect pollination was necessary for flowers to set pods.

The instrument developed by this Section for the simple and quick determination of current soil moisture status is now being manufactured and sold by a commercial firm.

Entomology

Studies have shown that the mortality in field populations of the cabbage root fly from natural causes was about 95 per cent and that 90 per cent of this occurred during the egg stage, the eggs being eaten by predatory beetles. Incorporation of insecticides in the soil at rates which were too low to kill the pest in the larval stage, could reduce the predatory effects of the beetles on the eggs and could result, therefore, in higher infestations than would occur naturally. This emphasises the need for care in applying insecticides in the proper manner and at the correct dose rates.

The control of carrot fly on carrots has been shown to be achieved effectively by the incorporation of the insecticides dieldrin or aldrin in the soil prior to sowing. The effectiveness of various methods of application of insecticide and of incorporating it in the soil, and of different depths of incorporation, have been determined by experiments, as were also the rates of application required to give satisfactory control on loam soil and on fen soil.

Work was continued on the biology of the carrot fly and on the control of this pest on parsnips. Dieldrin used as a seed dressing, as a spray on seedlings, and on crowns of plants during August, gave incomplete control. Seed dressings containing either gamma BHC or dieldrin were shown also to reduce germination considerably when a prolonged period of drought followed the sowing of dressed seed. Incorporation of insecticides in the soil appears to be a more promising method of control.

The attack of the root aphid on summer lettuce was less in 1958 than in the previous four years. A seed dressing containing endrin, supplemented by an endrin or diazinon spray applied to the seedlings soon after singling gave a high degree of control of the aphids. A similar result was obtained by incorporating either endrin or diazinon in the soil before sowing. Certain weeds have been found to be alternative host plants of the lettuce root aphid.

Investigations on the cumulative effect of the temperatures occurring under different soil conditions on the development of pea moth larvae, have led to the conclusion that the use of a day-degree method for predicting when pea moths will emerge in a pea crop is not likely to be of practical value. Prediction of the date of emergence would enable the crop to be sprayed with DDT emulsion at the proper time for control of the pest.

Work is in progress on the development of bioassay methods of determining the persistence of insecticidal residues in the soil, and the absorption of insecticides by plants.

Plant Pathology

Further tests have confirmed the effectiveness of seed treatment with the antibiotic streptomycin for the control of silvering disease of red beet. Streptomycin is now available for use by seed growers.

Both maneb and captan were again found to give good control of *Didymella* stem rot disease of outdoor tomatoes when sprayed on the lower stems of the plants every three weeks.

Work has been continued on the black type of canker of parsnips caused by species of the fungi *Itersonilia* and *Phoma*, and also on the orange-brown type. Field experiments suggest that later sowings of parsnips, e.g., June instead of March, will give a reduction in the loss from the disease. Further selection and testing has been carried out on strains of parsnips showing reduced susceptibility to canker.

Field experiments were carried out again at Luddington E.H.S. on the control of clubroot on summer cabbage. Several compounds were tested and some of them (especially aldrin) brought about a reduction in the disease and an increase in crop yield.

Studies have been made on leaf and pod spot disease of peas, and on methods of control. Certain fungicides reduced the amount of disease but it is doubtful whether the treatments would be satisfactory for use by growers.

Evidence now indicates that big vein disease of lettuce is widespread in England. Studies are in progress on the host range, and on the cause and means of controlling the disease.

Soil treatment with zinc in the form of zinc frit (powdered glass containing zinc) or of zinc sulphate has been found to give good control of powdery mildew on both turnips and cabbage.

'Botrilex' when mixed with the top soil of brassica seed-beds gave a considerable degree of control of *Rhizoctonia* damping off and wirestem disease. Its effect was similar to that of mercuric chloride but the latter has the disadvantage of being toxic to humans and sometimes is phytotoxic.

Weed Investigations

It has been reported previously that one year of vegetable cropping on very weedy corn land at Wellesbourne reduced the population of weed seeds in the soil to about half, and that the second year of vegetable cropping reduced the population to about one-fifth. The third year of vegetable cropping has now been found to have reduced the population of weed seeds in the soil to about one-sixth of the original number. Rotary cultivation did not reduce the number of weed seeds so effectively as ploughing, however, and rotavated plots contained far more seeds of annual meadow grass (*Poa annua*) than ploughed plots.

Further work with dinoseb (amine) has confirmed that it is useful as a residual pre-emergence herbicide with runner beans and dwarf French beans, and as a post-emergence herbicide with broad beans. Promising results were obtained with simazine when used as a residual pre-emergence herbicide with spring-sown field beans. It was also confirmed that sodium monochloroacetate was valuable for the control of chickweed (*Stellaria media*) and other broad-leaved weeds in spring cabbage when used as a post-emergence spray.

Encouraging results were obtained with ethylene dipyridylium dibromide as a contact pre-emergence herbicide with different vegetable crops, although it proved to be unsuitable as a post-emergence treatment. Trials of simazine as a residual pre-emergence herbicide applied to direct-sown sweet corn gave excellent results but information regarding persistence in the soil is required before it can be recommended for use.

Spray drift. Studies have been started on the effects of growth-regulator herbicidal sprays drifting on to vegetables. These will include the study of susceptibility of different vegetables to damage, and of the characteristic symptoms of injury and effects on yield and quality with different dose rates at different growth stages. A search will be made also for suitable indicator plants.

Statistics

Advice and assistance were given again to the research staff, and to the N.A.A.S. Experimental Horticulture Stations and other bodies. Owing to lack of success in filling a vacant post, however, some of the studies being carried out by the Section have had to be curtailed. Further progress was made with the fitting of curves to plant-growth data but the season was not a good one for testing different time scales for use in growth equations. Intensive weeding of red beet was again shown to give considerable improvement in the accuracy in experiments with this crop. On the other hand, a similar effect produced by chitting of red beet seed in 1957 was not produced in 1958, probably because of the moist soil conditions. Further work was carried out on the genetics of continuous variation in French beans.

The Director has continued to serve on the Advisory Committee of the N.A.A.S. Experimental Horticulture Stations, and to act as Chairman of the Vegetable Working Party which co-ordinates the experimental work on vegetables at these Stations. Mr. Nelder also served again on the Protected Cropping and Glasshouse Working Parties, and Mr. Winter also served again on the Protected Cropping Working Party. The close co-operation and friendly relationships between the Experimental Horticulture Stations and the N.V.R.S. have been maintained and we are grateful to them for having carried out field experiments with vegetables in extension of those done at Wellesbourne.

The National Institute of Agricultural Botany, Cambridge, again co-operated closely with this Station in seed maintenance and multiplication work and in the trials of varieties, and the Director continued to serve on the Vegetable Trials Advisory Committee of the N.I.A.B.

Mr. Wright continued to serve on the Advisory Committee and the Joint Panel of the Crop Protection Products Approval Scheme of the Ministry of Agriculture, Fisheries and Food. He also served on the Taint Committee of the Agricultural Improvement Council. Mr. Roberts served again on the Recommendations Committee of the British Weed Control Conference.

N.V.R.S. ASSOCIATION

1958 was marked in the history of the Station by the formation of the N.V.R.S. Association, a most important development in the Station's affairs. The N.V.R.S. Association has been set up to advance the knowledge, science and practice of vegetable production and it will enable members (whether growers or other interested persons or firms) to keep in touch with the latest research developments at the Station. They will receive copies of the Station's Annual Reports and be entitled to attend Members' Days.

These Days will provide opportunities for the interchange of ideas between research workers and members, and will enable growers to see and discuss work being done at the Station, to keep themselves abreast of the latest progress, and to meet other growers with common interests.

Rules of the Association were agreed upon at the Founders' Meeting held at the Station on 12th June 1958, and elections were made as follows :—

Chairman of the Association : David Lowe, Esq., Elvingston, Gladsmuir,
East Lothian.

Treasurer : Professor T. Wallace, 'Redwings', Old Church Road, Nailsea,
Somerset.

Secretary : G. Lesson, Esq., N.V.R.S.

Committee :—

T. W. Clucas, Esq., J. L. Clucas Limited, Ormskirk, Lancs.

W. Grant Currie, Esq., Circus Street, Brighton.

E. H. Gardener, Esq., Steinbrook, Kington Langley, Chippenham, Wilts.

H. W. Hughes, Esq., The Moat House, Abbots Salford, Evesham, Worcs.

J. Jesty, Esq., Bedford and Jesty Limited, Doddings, Wareham, Dorset.

David Lowe, Esq., (Chairman).

A. McWilliam, Esq., H. J. Heinz Company Limited, Harlesden, London, N.W.10.

R. L. Scarlett, Esq., Sweethope, Musselburgh, Midlothian.

J. A. Secrett, Esq., Hurst Farm, Milford, Godalming, Surrey.

W. F. Swift, Esq., Avon Cottage, Fladbury, Pershore, Worcs.

Professor T. Wallace.

Dr. J. Philp, Director of the Station. (Ex officio).

After the business meeting, the members were taken on a tour of the Station and were shown some of the work in progress in each of the sections of research.

A Members' Day was also held on 5th November, when members were shown the effects of up to three generations of inbreeding combined with selection in Brussels sprouts, and the highly promising results obtained from hybrids between these inbred lines—yield, quality and uniformity having been much improved as compared with the original parental varieties.

By the end of the year, membership had reached a total of 111. We are convinced that the Association will encourage closer ties between practice and research which will be of benefit to both sides and it is hoped that in future the membership will steadily increase. We are grateful to all those who helped in publicising the establishment of the Association, and especially the Press, the N.F.U. and the N.A.A.S. Forms of application for membership and copies of the rules of the Association may be obtained on request from the Secretary of the Station.

Visitors

The number of visitors to the Station during 1957–58 was 681 and it gave us special pleasure to have a visit from the Lord Rothschild, Chairman of the Agricultural Research Council, on 5th May.

The following visitors came from overseas :—

<i>Australia :</i>	Dr. O. H. Frankel, Chief of the Division of Plant Industry, C.S.I.R.O., Canberra.
	Professor J. S. Turner, the Botany Department, University of Melbourne.
	Dr. D. W. Goodall, Officer-in-Charge, C.S.I.R.O., Tobacco Research Institute, Mareeba, Queensland.
<i>Canada :</i>	Dr. Colin D. McKeen, Science Service Laboratory, Harrow, Ontario.
<i>Chile :</i>	Mr. D. E. Pavez de Saa, Ministry of Agriculture, Santiago.
<i>Finland :</i>	Miss Kirsti Salokangas, Agricultural Research Centre, Department of Horticulture, Piikkio.

<i>Germany :</i>	Six members of the German Federal Parliament. Mr. R. W. Hugemann, Dusseldorf.
<i>India :</i>	Mr. C. V. Govindaswamy, Colombo Plan Technical Co-operation Scheme. Mr. S. K. Mukherjee, Horticulturist to Government of West Bengal. Mr. Y. P. Shreevastava, Department of Agriculture, Extension Training Centre, Ranchi.
<i>Indonesia :</i>	Mr. B. K. Varma, Ministry of Food and Agriculture, New Delhi. Mr. S. Achmadhy } Mr. S. Soetantjo } Institute of Plant Diseases and Pests, Bogor, Java. Mr. P. Panoedjoe }
<i>Iran :</i>	Mr. A. G. Mirzai, Ministry of Agriculture, Ahwaz.
<i>Israel :</i>	Mrs. H. Gelmond-Gavrielit, Head of Seed Testing Laboratory, Government Agricultural Research Station, Rehovot.
<i>Malaya :</i>	Mr. Philip Lai, Dunlop Malayan Estates Ltd.
<i>Pakistan :</i>	Mr. A-D. Khan, Tarnab Farm, Peshawar. Mr. S. N. A. Gilani, Pakistan Secretariat, Karachi.
<i>Philippines :</i>	Mr. T. S. Batin, Bureau of Plant Industry, Andres, Manila. Mr. B. A. Revilla, University College of Agriculture, Laguna.
<i>Poland :</i>	Professor and Mrs. E. Chroboczek, College of Agriculture, Institute of Vegetable Crops, Skierniewice.
<i>South Africa :</i>	Mr. R. B. Fyfe, Yarrow, Hawick, Natal.
<i>S. Rhodesia :</i>	Dr. R. N. Graham, Henderson Research Station.
<i>Switzerland :</i>	Dr. L. E. Cawart, Basle.
<i>Turkey :</i>	Mr. I. Sengezer, Ministry of Agriculture, Ankara.
<i>U.S.A. :</i>	Dr. P. B. Lecompte, Agricultural Experiment Station, Rutgers University, New Brunswick, N.J. Dr. R. Hopp, University of Vermont, Burlington, 4. Dr. P. Work, Cornell University, Ithaca. Mr. W. A. Rawlins, Cornell University, Ithaca.
<i>Yugoslavia :</i>	Mr. Ilija Kolaric, Institution for Fruit Growing, Zagreb. Ing. Radisa Mijajlovic, Belgrade. Mr. Jezdimir Nikolic, Valjevo. Mr. Mita Pandurov, Subotica. Ing. Vladimir Petrovic, Zemun. Mr. Milan Rovani, Secretariat for Agriculture and Forestry, Ljubljana. Mr. France Sitar, Institute of Agriculture, Maribor. Mr. Boris Zivec, Director of Agricultural Station, Zacreteje. Mrs. D. Gajic, Institute of Biology, Belgrade. Mr. A. Blanka, Institute for Plant Protection, Zagreb.

In addition, the following 22 parties visited the Station :—

1957		
1st November	...	Staff of the Botany Department, University of Manchester.
1958		
14th April	...	Staff and students from the University College of Wales, Institute of Rural Science, Penglais, Aberystwyth.
6th May	...	Members of the Protected Cropping Working Party of the Agricultural Improvement Council.
30th May	...	N.A.A.S. Officers from Wales.
3rd June	...	N.A.A.S. Regional Directors.
6th June	...	Dr. John L. Harper and students from the University of Oxford.
13th June	...	Horticultural advisers from Levington Research Station, Ipswich.
17th June	...	N.I.A.B. Variety Trials Committee.
19th June	...	N.P.K. Club.
21st June	...	F.A. Secrett Trainees Club.
24th June	...	Members of the Pershore Branch of the National Farmers' Union.
26th June	...	N.A.A.S. Entomologists.
p.m. 7th July	...	Members of the Banbury and District Horticultural Society. Members of the Stratford-upon-Avon Young Conservative Association. Members of the Coventry Cyclists Club.
10th July	...	N.A.A.S. Officers from the West-Midland Region.
18th July	...	Members of the British Mycological Society.
24th and 25th July	...	N.A.A.S. Horticultural Advisory Officers.
28th July	...	Students from Coventry Technical College.
29th July	...	Members of the Committee on Transactions in Seeds—Plant Breeders' Rights.
13th August	...	Staff and students of the Botany Department, University of Birmingham.
2nd September	...	Members of the N.F.U. Headquarters Vegetables Committee.

Acknowledgments

Special thanks are due to members of the staff who have carried out duties in addition to their normal work. Mr. Winter and Mr. Wheatley gave assistance in connection with special services needed for the new buildings and Dr. Keyworth co-ordinated the requirements regarding fixed fittings. Valuable service was also given by the following committees :— Canteen Committee—Mr. Bartlett (Treasurer), Dr. Bleasdale (Chairman), Miss Howell, Dr. Johnson, Miss Kullman (Secretary), and Mr. Winter; Glasshouse Committee—Dr. Haigh, Dr. Keyworth, Mr. Norwood, Mr. Winter and Mr. Wright; Library Committee—Dr. Haworth, Miss Moore, Mr. Nelder and Mr. Roberts.

Grateful acknowledgment is also made to other members of the staff who helped in various ways, and to all the staff and employees for the loyalty with which they carried out their work.

Thanks are due to the Executive Committee and the Sub-Committees, and especially to the Chairman of the Governing Body and the Chairmen of the Committees for the assistance they have given. It was with great regret that we lost the services of Mr. A. A. Clucas who resigned from the Governing Body in February 1958 owing to ill health. He was a member of the Governing Body from its inception, and was also a member of two Sub-Committees—Staff and Research, and Varieties Inspection. We are grateful to him for the help he has given and for his benefactions to the Station. We are very sorry also to have lost the services of four other members of the Governing Body on completion of their term of office in September 1958. Professor Munro and Mr. Scarlett have been members of the Governing Body since it was first established. Both have served on the Executive Committee and on the Staff and Research Sub-Committee, and Mr. Scarlett was also a member of the Farm Management Sub-Committee. We thank them for their services and for much assistance given in other ways. Mr. Boardman served on the Farm Management Sub-Committee for six years and we are grateful to him for the help he has given especially regarding Paglesham Sub-Station. Mr. Thoday is thanked for the keen interest he took in the affairs of the Station.

Grateful acknowledgment is due to the Pharmaceutical Society (Scottish Branch) who, through Dr. Nelson of the University of Edinburgh, kindly presented volumes I–IX of the *Journal of Botany* (1863–1941) to the Station's library.

We also wish to thank all our friends outside the Station, especially growers and commercial firms, who have kindly given seeds, plants and other material, and who have helped in many other ways during the year.

J. PHILP,

19th February 1959.

FARM

By T. J. NORWOOD

Wellesbourne

During the year under review the cropping of the farm followed closely on the lines already established in previous years.

The overwintered vegetables such as spring cabbage and peas, early summer cauliflower and lettuce had a difficult time during March and early April but vegetable growth afterwards was rapid and crop yields and quality were good. The summer-planted vegetables such as Brussels sprouts, winter cabbage and broccoli grew quickly after transplanting but peas and beans tended to grow too much haulm, and pea picking in consequence was difficult.

The only variety of main crop potatoes grown was Majestic and, although the tops were badly attacked by blight and were eventually killed off by spraying on 30th August, the yield was well up to the average on the farm and the tubers have kept well in store.

Approximately 100 acres of cereals were grown, two-thirds of the acreage being barley for home milling for pig food. The 29 acres of wheat stood up to the weather very well and were harvested in good condition but the oats lodged badly and were very difficult to harvest.

Of the total of 82 acres of grass, 30 were grazed by cattle and brood sows and the remainder was cut for silage and hay. About 60 tons of hay was made but owing to the wet weather some of it was of rather poor quality. About 200 tons of silage was made in a surface clamp in a Dutch barn, the outdoor silage pits having become water-logged. This resulted in the final product having a higher dry matter content than comparable samples in previous years and being much more easily handled in wet weather.

80 Hereford cattle were bought in the autumn and fed in the yards during the winter. Of these, 44 were sold direct from the yard as fat steers and the remainder were fattened-off on the grass and sold during the summer. During the year, 47 litters of pigs were born and the average number of piglets reared per litter was 8.1. Most of these pigs were sold later for bacon. Approximately 600 tons of farmyard manure was produced by these animals and this has been ploughed into the fields for experimental vegetable crops.

Paglesham

The cropping at Paglesham was about equally divided between vegetables including potatoes, cereals and grass.

The main vegetable crops, onions and Brussels sprouts grown for selection and seed production, yielded very satisfactory crops.

While the cereals grew well and yields would have been above average, great difficulties were experienced in harvesting, and lodging of the crops, with consequent shedding of grain, led to an overall reduction in the yield.

King Edward potatoes were a disappointing crop and kept badly in store but the Majestics, although going down early with blight, yielded a good average crop and kept well in store.

During the year under review 26 cattle were bought as stores. These, together with 24 bought earlier, were fed in the yards and grazed on the leys and subsequently sold for beef. The small herd of breeding sows has been maintained and the progeny fed to bacon weight.

During the late summer a new steel and asbestos barn 75 ft. by 45 ft. was erected and is being used as a potato store.

PLANT BREEDING REPORT

By J. C. HAIGH

BREEDING PROJECTS

In addition to the work reported below, progress has been made towards breeding disease-resistant lettuce, non-bolting Detroit beet, hybrid onions and a winter cabbage free of rosette-type heads. Details will appear in the next report.

Brussels sprouts (A. G. Johnson and G. J. Faulkner)

Test crosses between selected inbred lines of Brussels sprouts were grown in 1956 in order to provide data on combining ability and on hybrid vigour. The first trial was of hybrids between selected S_2 and S_3 plants of the variety Cambridge Special. General vigour was slightly greater than that of non-inbred Cambridge Special and eight of the nine hybrid families tested gave a slightly greater total yield than the parent variety. At a plant spacing of 2 ft. 6 inches square the best family of these hybrids, however, gave a yield equivalent to 7.3 tons per acre of marketable sprouts, which was 41 per cent better than that given by the parent variety.

The second trial was of hybrids between the same selected S_2 and S_3 plants of Cambridge Special and selected S_1 plants of Cambridge No. 1. Vigour was again slightly greater than that of non-inbred material and most of the hybrids had the dark leaf and sprout colour, and the high sprout quality of the Cambridge Special parent. Of 16 hybrid families tested, all but one gave a slightly greater total yield than the higher-yielding parent variety, Cambridge No. 1. At a spacing of 3 ft. square the best family of these hybrids gave a yield equivalent to 7.6 tons per acre of marketable sprouts. This was better by 64 per cent than that of Cambridge No. 1, and 78 per cent better than that of the mean yield of marketable sprouts of the two parental varieties.

An improved strain, produced by progeny testing (3, 5), of the variety Cambridge Special gave a yield of marketable sprouts which was 10 per cent better than that of the non-progeny-tested strain from which the parent plants had been selected. This increase was less than had been obtained by the progeny-testing technique in the varieties Cambridge No. 1 and Cambridge No. 3, which are more variable than Cambridge Special and so offer greater scope for improvement.

Peas (H. Holland and G. J. Frost)

In continuation of the attempt to produce a winter hardy, early maturing culinary pea of good quality (1), seeds from F_1 plants (F_2 material) from crosses between round-seeded Austrian winter maple and wrinkled-seeded culinary varieties were sown in the field on 1st-2nd November 1957. Round and wrinkled seeds from each F_1 family were sown separately. Counts were made after each period of frost and two facts emerge from the data. One is that the initial stand of plants grown from wrinkled seed was significantly lower than that of plants grown from round seed. This may merely mean that wrinkled seed needs a higher temperature than round seed to induce germination, or it may mean that newly-germinated wrinkled seeds were killed before the plumule appeared above ground. Later spells of hard weather killed established plants more extensively among those grown from wrinkled seed; all plants of the wrinkled-seeded parents of the crosses were killed. The other fact is that hybrid derivatives grown from wrinkled seed survived throughout the season, so that the combination of winter hardiness and wrinkled seed (and presumably, therefore, of quality), is possible. From these survivors, plants combining wrinkled seed, white flower and determinate habit were selected for further work to be done on them.

Spring cabbage (A. G. Johnson and G. J. Faulkner)

As a result of the survey of spring cabbage varieties which was reported in 1956 (2), plants were selected from the best varieties, for use in a breeding programme. These

plants were selfed and also pair-crossed both within and between varieties and the progenies were grown in 1957-58. Three varieties produced progenies which were consistently superior in all combinations. The best individual progeny (a pair-cross within one of the varieties) was ready to cut as spring greens about 10 days before any other, and remained fit to be marketed as 'hearted cabbage' 5-6 weeks later. The prospects of producing a dual-purpose variety are therefore promising. Plants have been selected from several progenies for further breeding work.

About 90 per cent of the plants raised from exceptionally early sowings bolted (4). Selected non-bolting plants were self-pollinated and also crossed in pairs and the seed thus obtained was sown again exceptionally early in 1957. No plant from this seed bolted early but there was only 5 per cent of early bolting in plants of the parent variety raised at the same time, so that the conditions of the 1957 season were not such as to induce bolting even with early sown seed.

Early summer cauliflower (L. E. Watts and R. A. T. George)

Cambridge No. 5 is the earliest summer cauliflower variety on the market but its quality leaves much to be desired. Work was started in 1954 (7) with the dual purpose of getting better quality in an even earlier strain. Two methods were used. In one, inbred lines of Cambridge No. 5 were selected for a combination of earliness and quality; in the other, Cambridge No. 5 was crossed with a Dutch variety (van den Berg's No. 35) in an attempt to combine the earliness of one with the quality of the other.

Table I summarises the progress made in the first three years of inbreeding. The first three columns of figures give the numbers of days earlier (—) or later (+) by which the date of '50 per cent cut' of the inbred lines differed from that of the non-inbred

TABLE I
Early summer cauliflower, Cambridge No. 5

Inbred line	Differences in date of 50% cut (days)			Differences in % perfect curds		
	S ₁ (1956)	S ₂ (1957)	S ₃ (1958)	S ₁ (1956)	S ₂ (1957)	S ₃ (1958)
A	— 9	— 7	0	+ 25	+ 48	+ 29
B	— 5	— 4	+ 1	+ 14	+ 22	— 20
C	— 7	— 3	— 2	+ 27	+ 28	— 13
D	— 8	— 4	— 3	+ 4	— 21	— 16
E	— 3	0	not present	+ 5	+ 5	not present
F	— 1	+ 1	0	+ 1	— 12	0
G	— 2	— 1	not present	+ 7	+ 11	not present
H	— 6	— 1	— 4	+ 31	+ 45	+ 12
I	— 5	not present	— 1*	+ 37	not present	+ 38*
Cambridge No. 5 (Control)	18th June	2nd June	15th June	5%	31%	23%

*this was an S₂

control. The second three columns give the differences in percentages of perfect heads between the inbred lines and the control Cambridge No. 5. The data are given as differences because of the considerable variation in the expression of both parameters produced from year to year by environmental factors.

In each inbred generation, the earliest perfect curds of grade not less than 24 ($4\frac{1}{4}$ – $5\frac{1}{4}$ inches diameter) were selected for propagation, but such curds were never found at the first cut. Of the original 14 S_1 lines, three failed to set seed and two were discarded because of inferior quality. The table shows that, in general, the earliness and quality gained in the first inbred generation are steadily being lost in successive inbred generations, but that in a few lines the quality appears to be maintained. Selections from the best lines will be kept for trial in 1959.

The Dutch variety No. 35 matures about a week later than Cambridge No. 5 but is of much better quality. The two varieties were crossed in 1955, and in 1956 part of the F_1 generation was backcrossed to No. 35 and the rest of the F_1 was selfed to produce an F_2 generation. In 1957, F_2 and BC_1 (first backcross) plants selected for earliness and quality were selfed and their progenies grown in 1958. Table II shows the relationship between the date of 50 per cent cut of the early parent Cambridge No. 5, No. 35 and the progenies, and the corresponding percentages of perfect curds. The F_1 generation was so small that the data taken from it are not thought to be reliable. Selections were made in 1958 from both F_3 and BC_1 selfed progenies for further breeding work but it would appear to be difficult to combine the earliness of one variety with the superior quality of the other.

TABLE II
Early summer cauliflower

Varieties and generations	Date of 50% cut (days) relative to Cambridge No. 5	% perfect curds
Cambridge No. 5 ...	0	30
No. 35	+ 7	78
F_2	+ 3	53
BC_1	+ 4	68
F_3	+ 3	50
BC_1 selfed	+ 5	60

Asparagus (J. C. Haigh)

'Super male' asparagus plants have been bred which give an all-male progeny when crossed with normal female plants. It is likely that there will be advantages in growing only plants of the male sex in a commercial holding, but it is also likely that such a practice will involve changes in cultural procedure, for example in spacing. There is a tendency in many holdings to plant crowns closely together in anticipation of the gaps which will be produced by the death of the shorter-lived female plants. If all the plants of an all-male progeny can be expected to live to approximately the same age, then perhaps they can be spaced more widely than usual and will live even longer and yield more heavily. Spacing trials will be necessary to check this point.

'Super males' are derived from andromonoecious males, which form 1-2 per cent of the male plants of an ordinary population of asparagus. Most of these abnormal males bear only a few berries, but occasionally one is found which is almost hermaphrodite, i.e., almost fully berried. It is possible that selection for this last type could recreate the hermaphrodite form from which dioecious asparagus has probably arisen by mutation.

Tomatoes (J. C. Haigh)

In the course of work on stem and fruit rot of outdoor tomatoes caused by *Didymella lycopersici* Kleb, Dr. Knight of the Pathology Section found that a strain of *Lycopersicon hirsutum* was highly resistant to stem and root infection by *Didymella* (6). F_1 hybrids between plants of this strain and plants of a cultivated tomato variety have proved under test to be as resistant as the *hirsutum* parent. A backcross programme has been started to transfer the resistance of *L. hirsutum* to varieties of cultivated tomato.

The genus to which the tomato belongs (*Lycopersicon*) is divided into two sub-genera, *Eriopersicon* and *Eulycopersicon*, and crosses between members of the two can be made only when the species of *Eriopersicon* is used as the male parent. Likewise, F_1 hybrids will mate in backcrosses to species of *Eulycopersicon* only as male parents, and to species of *Eriopersicon* only as females. Most of the *Eriopersicons* are self-incompatible under our conditions and pass on this incompatibility as a dominant character to hybrids with *Eulycopersicon*.

The situations described above apply to the project in hand since *L. hirsutum* belongs to *Eriopersicon* and *L. esculentum* to *Eulycopersicon*. In consequence, F_2 and succeeding hybrid generations are difficult to get and a backcross technique becomes necessary. It is fortunate that this technique is the one most likely to produce the desired result.

Celery (A. G. Johnson and G. J. Faulkner)

An attempt is being made to improve the quality of self-blanching celery by crossing it with green celery. Since celery is self-fertile and emasculation is both laborious and uncertain of result, preliminary work has been done to determine whether hybrids can be produced between these two types without emasculation, and whether the hybrids can be readily recognised. Green celery plants crossed, without emasculation, by pollen from self-blanching plants gave seedling progenies which were all green and, therefore, hybrids if present could not be recognised. In contrast, seed from self-blanching plants of two varieties when pollinated, without emasculation, by pollen from green plants of three varieties gave a wide range in the proportion of green plants in the progeny, varying from 7 per cent to 95 per cent according to the varieties used in making the cross—the remainder being pale green like the self-blanching parent. The green and self-blanching seedlings in the mixed progeny could be distinguished by a difference in depth of green colour at the opening of the second true leaf. The self-blanching plants in the progeny bred true when selfed, and the green plants, when selfed, gave green seedlings, one quarter of which subsequently developed yellow leaves. It follows, therefore, that when self-blanching plants are used as females, without emasculation, in crosses with green plants, the hybrid seedlings in the resulting progenies can be recognised by their colour.

SEED PRODUCTION

Nucleus stock seed was produced of the following varieties :—

Brussels sprouts	..	..	Cambridge No. 1	} at Wellesbourne.
Brussels sprouts	..	..	Cambridge Special	
Early summer cauliflower	..	..	Cambridge No. 5	
Onion	..	..	Cambridge No. 10	at Paglesham.

Plants were grown and selected for the production in 1959 of nucleus stock seed of the following varieties :—

Brussels sprouts	..	..	Cambridge Special	at Wellesbourne.
Onion	..	..	Cambridge No. 10	at Wellesbourne.
Onion	..	..	Cambridge No. 10	at Paglesham.

WORK AT OUTSIDE CENTRES

Facilities were again provided at Luddington E.H.S. for observing the incidence of clubroot on some cabbage varieties. Spacing trials with two quick-freeze Brussels sprout varieties, Cambridge Special and the new variety Irish Glacier, were planted at Efford, Luddington and Stockbridge E.H.S.'s. Selections of Roscoff broccoli were made at Rosewarne E.H.S. It is again a pleasure to record our appreciation of the co-operation so readily given by the Directors and staffs of these Stations.

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CHEMISTRY REPORT

By F. HAWORTH

FIELD EXPERIMENTS

The mild winter and early spring of 1957-58 encouraged the early growth of spring cabbage and winter lettuce. The sharp frosts in mid-March, however, caused the spring cabbage plants which had received low levels of nitrogen fertiliser to turn blue, whereas plants which had received applications of FYM or higher levels of nitrogenous fertiliser remained green. The discoloured plants slowly recovered their normal colour and were saleable at harvest in May. The wet conditions in March made soil preparation for the early crops difficult and also prevented effective weeding operations.

The pattern of yields described in earlier reports (2, 3) was maintained for crops on the nitrogen and NPK-FYM factorial experiments but the responses of leeks, Brussels sprouts and peas to the different cultivation treatments of the cultivation experiment were not the same as in previous years.

Cultivation experiment

Deep ploughing, shallow ploughing with subsoiling, and shallow ploughing did not differ in their effects on the yields of leeks (harvested December 1957) and of Brussels sprouts (harvested October 1957 to February 1958) and gave higher yields than shallow rotavating as a primary cultivation. In previous years the former two treatments gave higher yields, in general, than the latter two treatments with these crops.

The pea crop was sown rather later than usual and matured slowly in the wet and cool conditions of late July and early August. Shallow ploughing or shallow rotavating gave similar yields of pods which were higher than those from deep ploughing or shallow ploughing with subsoiling but, on account of the high standard error of this experimental crop, only the yield difference brought about by shallow ploughing, as compared with shallow ploughing with subsoiling, reached statistical significance. This is the first time that any of these primary cultivation treatments have shown marked differences in their effects on the yield of marketable pods.

Plots which had received only nitrogenous fertilisers for five years gave about 30 per cent lower yields of both Brussels sprouts and spring cabbage, and about 60 per cent lower yields of leeks than plots which had received annual applications of FYM and phosphatic and potassic fertilisers over the same period. Chemical analysis showed that with the nitrogenous fertiliser treatment the leek leaves contained much less phosphate and potash than leaves from the FYM, phosphatic and potassic fertiliser treatment, whereas this did not apply to such a marked extent with the two brassicas. The results suggest, therefore, that the leeks were more sensitive than the brassicas to phosphate and potash deficiency conditions in the soil. The leek and Brussels sprout crops planted in May-June 1958 had not been harvested at the time of writing.

Nitrogen experiment

The four crops harvested from this experiment during 1958, leeks, early potatoes, spring cabbage and summer cabbage, showed large increases in yield attributable to applications of FYM. In the presence of FYM the lowest rate of nitrogenous fertiliser gave lower yields of early potatoes and the two brassicas than the other nitrogen treatments but the yield of leeks was the same from all the nitrogen treatments. Where no FYM had been applied, inorganic nitrogen in one dose gave the highest yield of early potatoes, spring cabbage and summer cabbage, whereas the highest yield of leeks was obtained where the nitrogenous fertiliser had been applied in four (smaller) doses. All the plots of this experiment had received an annual base dressing of phosphatic and potassic fertilisers in addition to the experimental fertiliser treatments, but chemical analysis showed that the percentage of potassium in the leaves of early potatoes from plots treated only with inorganic fertilisers for five years was much lower than in leaves

from plots treated with annual applications of FYM, and was approaching a deficiency level. Analysis of a comparable series of leaf samples taken from the 1957 crop did not show such a marked difference in the potash contents and did not suggest that a shortage of potash in the soil was seriously affecting yields on the no-FYM plots.

NPK-FYM factorial experiment

A shortage of spring cabbage plants in September 1957 necessitated the sowing of an alternative crop on Phase I of this experiment. Seed of the winter lettuce, variety Imperial, was drilled in late September and the crop was thinned in early March. This crop responded rapidly to the different manurial treatments, and even when the plants had only two leaves it was possible to recognise all the plots which had received FYM as part of their manurial treatment by the more uniform stand and greater size of the plants. At harvest in May 1958, it was found that the yield of saleable lettuce from plots which had received FYM was more than double that from plots which had received only inorganic fertilisers. In the absence of FYM, increases in yield were recorded which were attributable to the applications of phosphatic and potassic fertilisers but responses to these fertilisers were not obtained where FYM had been applied.

The carrot crop was adversely affected by the cool, wet weather of the summer and autumn, and although a fairly heavy total yield was obtained, only one half of this was saleable. Many carrots were cracked and the condition known as 'clayburn' (4) was prevalent. The cause of this condition is not known. The effect of manurial treatments on the incidence of 'clayburn' was investigated by the Plant Physiology Section (1) and it would appear from the results obtained that the balance of potassium and nitrogen in the soil may be one of the factors associated with splitting and 'clayburn' of carrots. However, the highest yields of marketable carrots were obtained from the FYM series of plots and, in the absence of FYM, from those plots which had received the highest rate of application of potassic fertilisers.

Self-blanching celery

Studies of the possible causes of internal breakdown of self-blanching celery have been continued but, for the second successive year, the amount of the disorder found in the experimental crops was small.

Runner beans

The experiment (3), started in 1957 to measure the response of runner beans to soil physical conditions and nutrient supply, was continued. Six treatments were used in 1957 only :—control, FYM (30 tons per acre), peat (5 tons organic matter per acre), fertiliser (150 lb. N, 60 lb. P_2O_5 , 240 lb. K_2O , each per acre), peat with fertiliser, and FYM with fertiliser. In 1957 the most striking response was to the FYM treatment. Chemical analysis showed that the mineral composition of plants from plots which had not received FYM was similar to that expected in plants grown under acid conditions. Although the pH of the soil was about 6.2, two of the four replicates of the experiment were limed at the rate of two tons per acre of ground limestone in February 1958. No further organic or inorganic manures were applied to the plots so that in 1958 the residual effects of the treatments applied in 1957 were measured. The yield results obtained are shown below.

Yield of runner beans. kgs. per 4 × 20 sq. yard

Treatment			No fertiliser		Fertiliser	
			1957	1958	1957	1958
Control	..	..	24.2	42.2	84.9	121.6
Peat	..	..	38.6	54.8	109.8	145.1
FYM	..	..	189.6	145.4	200.4	164.4

The order of merit of yield effect of the treatments was the same in both years, but the percentage increase in yield produced by each treatment was less in 1958 than in 1957 which was not unexpected since only residual effects were obtained in 1958. It is noteworthy, however, that the extreme superiority of the FYM, and FYM with fertiliser treatments over all others in 1957 was not maintained in 1958. In 1957 the peat with fertiliser treatment gave only about 50 per cent of the yield of the FYM with fertiliser treatment, whereas the results of experiments in pots in the glasshouse had indicated that similar yields could be expected from these two treatments. In 1958, on the other hand, the residual effects of these treatments on yield differed by only about 15 per cent. Chemical analysis of leaf samples gave results which were in line with these yield effects in that the differences in the potash content of leaves from the peat with fertiliser, and the FYM with fertiliser treatments in 1958 were smaller than the differences found between corresponding samples in 1957. The liming treatment had no effect on yield of beans, and had little effect on the mineral composition of the leaves.

Spring cabbage

During March 1958, four experiments on the nitrogenous manuring of spring cabbage were laid down on farms in the Vale of Evesham, with the kind co-operation of growers and of officers of the N.A.A.S. The results showed that, provided the nitrogen supply was the main limiting factor controlling growth, applications of up to 18 cwt. per acre of nitrochalk produced responses in yield which were economically worth while, and that the nitrogenous top dressing should be applied in one large dose rather than in three smaller doses. These results were similar to those described previously (3), although the rates of application of the nitrogenous fertilisers were higher than those used in the nitrogen experiment at Wellesbourne.

The application of 18 cwt. per acre of nitrochalk increased the amount of soluble nitrogenous compounds in the cabbage leaves at harvesting by about 25 per cent. Since these compounds could be concerned with the keeping qualities of the produce after cutting, further studies are being made on the effect of different rates of application of nitrogenous fertilisers on the proportions of the various nitrogenous compounds in cabbage.

FLOWERING OF RED BEET PLANTS (S. P. Spragg and J. Clare Hughes)

The investigation begun in 1957 (3) into the changes in the amounts of sugars, aminoacids and various phosphate fractions in the roots of red beet plants growing at different temperatures was continued.

Red beet plants grown from seed sown in late March or early April, flowered in June of the same year. Analysis of the roots of these plants at intervals during growth showed that, immediately prior to the appearance of the flower stalk, there was an accumulation of sucrose, fructose and glucose and a rapid decrease in the quantity of phosphorylated intermediaries. These changes did not take place in the roots of plants grown from seed sown in early May and which remained in the vegetative state during their first season of growth.

Studies on plants during and following periods of cold treatments given under controlled conditions, confirmed that the organic phosphates and the sugars were intimately connected with the flower induction process. The results showed that the metabolism of phosphorylated compounds in the root tissues was extremely sensitive to temperature changes and that hexose sugars accumulated in cold-treated roots after transfer to warm conditions. The results obtained with the relatively crude methods of fractionation used, suggested that the cold treatment inhibited the glycolytic system of the plant. This work is being extended to study in more detail the effects of cold on the metabolism of the phosphorylated compounds in the roots.

GERMINATION OF SEEDS (S. P. Spragg and J. Clare Hughes)

Work on this topic continued to be restricted to the pea seed and three arbitrary stages of germination have been used. The first is the absorption of water and the

accompanying activation of the cellular processes of the dormant seed ; the second is cell enlargement ; and the third stage is cell division. The last two stages are not rigidly defined and overlap to a considerable degree. Information concerning the chemical changes taking place during the first and third stages of germination has been obtained.

By means of analyses and the use of specific chemical inhibitors it has been demonstrated that the first stage of germination is dependent on the presence of sulphydryl groups in the uncombined state on the proteins, and of reduced thiols in the cell solution. The metabolism of the seed is extremely sensitive to compounds which react with these groups. The third stage of germination was studied using maleic hydrazide as a specific inhibitor. This chemical prevents plant cells from dividing and the study of pea seedlings treated with maleic hydrazide has shown that cell division is also dependent on a balance between the two oxidation states of glutathione. This balance appears to be related enzymically to changes in the protein sulphydryl groups. A study of the action of further mitotic inhibitors is contemplated in order to obtain more chemical information about cell division in the third stage of the germination of seeds.

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PLANT PHYSIOLOGY REPORT

By E. J. WINTER

In addition to the main work of the Section on competition and on growth analysis, especially of the crops produced on the Chemistry Section's manurial experiments, several minor investigations were continued. These included work on the vernalisation of peas and on dormancy in rhubarb, and a number of *ad hoc* tests of materials and methods were made to help in the design of the controlled environment rooms and their equipment for the main block of laboratories now being built. Members of the Section visited installations, and had discussions and correspondence with authorities on this subject.

Mr. R. Prieto-Ruiz, a Venezuelan student of Reading University, worked in the Section for the academic year 1957-58.

Apparatus for growing plants in the glasshouse under different daylengths was designed and constructed. Three of the glasshouse compartments were equipped with cycling thermostats which provide a continuous diurnal fluctuation in temperature.

COMPETITION STUDIES (J. K. A. Bleasdale)

The experiment on the weeding of main crop onions (3) has been repeated for a third year. Although the weed stands were higher than in previous years, date of weeding affected the final yield only at the higher of the two weed stands (12.5 weeds per foot of row). Plots weeded 12 days after the emergence of the onions yielded the equivalent of 17.0 tons per acre, whereas plots weeded 15 days later yielded only 15.3 tons per acre. The results of this experiment confirmed those obtained in 1956 and 1957 which will be published in detail elsewhere.

Further work has been done to ascertain the quantitative relationship between the degree of weed infestation and crop yield. Data obtained in 1957 were analysed to test the hypothesis that the following mathematical model would describe competition between two species A and B :—

$$\frac{\text{R.G.R.* of wt. } W_1 \text{ of A in the presence of wt. } W_2 \text{ of B}}{\text{R.G.R. of A alone at wt. } W_1} + \frac{\text{R.G.R. of wt. } W_2 \text{ of B in the presence of wt. } W_1 \text{ of A}}{\text{R.G.R. of B alone at wt. } W_2} = 1$$

This model did not describe the situation satisfactorily and, using an analogue computer, another model was tested in which it was assumed that the relative growth rates of A in competition with B were linear functions of the weights of A and B at that time. Within the limits of the data available this model appeared adequately to describe the results but further data on competition between carrot and chickweed (*Stellaria media* L.) obtained during 1958 will be used for a more precise test of the hypothesis.

The effects of spatial arrangement of plants on crop yield have been studied in the field. In 1958 the yield of peas, sown at one density per unit area, was adversely affected by close row spacing as compared with wide spacing. This result conflicts with data available for other crops. The 1958 growing season was abnormally wet and apparently favoured the excessive growth of haulm but it is not known how far this might have affected the result.

*Relative Growth Rate.

An experiment on the spatial arrangement of carrots confirmed the results obtained in 1957. Spacing the rows 12 inches apart increased the marketable yield by 25 per cent as compared with 24-inch spacing. A practice often adopted commercially is to have pairs of rows six inches apart with 18 inches between the pairs. This arrangement yielded 7.5 per cent less of marketable crop than the 12-inch spacing but the difference was not significant.

GROWTH STUDIES (R. B. Austin)

As in 1957 (2), a growth analysis was carried out on the carrot crop, variety Clucas' New Model, on 16 of the plots of the Chemistry Section's NPK-FYM factorial experiment (6). The 16 plots represented every combination of four factors at the lowest and highest levels used in the main experiment, namely : 15.5 and 46.5 lb. nitrogen per acre, 0 and 36 lb. phosphate (P_2O_5) per acre, 0 and 96 lb. potash (K_2O) per acre, and 0 and 20 tons of farmyard manure per acre. The seed was sown on 18th June 1958, and the first of a series of samples of plants was taken on 4th July, when the overall dry weight per plant was 1.9 mg. Each sample consisted of ten plants taken at random from each of the 16 plots.

Growth curves were constructed by plotting fresh and dry weights of roots and leaves against various 'time scales', including age in days, solar radiation in gram calories per sq. cm. and day-degrees above $42^\circ F$. On 4th July, there were no differences between the weights of plants from the plots. From 4th-30th July, growth was exponential when plotted against accumulated solar radiation, and the relative growth rate of plants from plots which had received FYM was 22 per cent greater than that of plants which had not received FYM, and the plants weighed 2.9 times as much as those from plots which had not received FYM. From 30th July to harvest in November, this ratio decreased to 1.4. None of the other treatments had a significant effect on plant weight during growth or on relative growth rate.

The final yield data, based on a harvest of one-fifth of the area of each plot, indicated the same pattern of response to treatments as in the previous year. The application of 20 tons of FYM per acre significantly increased the yield of roots from the equivalent of 15.3 (control) to 18.9 tons per acre. The effects of the other treatments did not differ significantly.

In 1958 an average of 30 per cent of the carrot roots were split and 15 per cent were 'clayburnt'. Clayburnt carrots were characterised by irregular purple patches on the tap root, the discolouration extending inwards up to 5 mm. from the root surface. As far as it is known (9) no pathogen is associated causally with clayburn. Examination of samples of roots from all plots of the experiment showed that the frequency of clayburn was increased by potash, decreased by nitrogen and slightly decreased by FYM application, and that there was a higher percentage of split carrots on plots which received potash or FYM than on plots which received the higher nitrogen dressings.

A more detailed mathematical treatment of the 1957 carrot growth data from the same experimental area was carried out in 1958 in collaboration with Mr. J. A. Nelder. By arrangement with the Statistical Department of Rothamsted Experimental Station, curves obtained by plotting leaf weight, root weight and total plant weight separately against four different time scales were tested for agreement with the logistic equation of growth :—

$$W = \frac{a}{1 + be^{-kt}}$$

Growth of leaves, but not of roots, was adequately described by the logistic equation. A mathematical model is being developed to describe root growth where growth of leaves is logistic.

Chemical analysis of the dry matter of successive samples from the 1957 carrot crop indicated that the main effect of applications of FYM was to increase the potassium content in leaf dry matter from 1.3 to 6.3 per cent. The highest application of inorganic potash, 96 lb. K_2O per acre, increased the potassium content in the leaf dry matter from 1.3 to 3.3 per cent.

ONION INVESTIGATIONS (R. B. Austin)

Pickling onions. In extension of previous work (1), a trial having the following treatments was carried out at Efford E.H.S. in 1958 :—

Varieties—Giant Zittau, German Pickler (Thoday's), Rijnsburger and New Brown Pickling (Thoday's).

Rates of sowing—20, 30 and 40 lb. seed per acre.

Dates of sowing—21st March and 17th April 1958.

The plots were dressed with 10 cwt. of inorganic fertiliser containing 5 per cent nitrogen, 12.5 per cent phosphate (P_2O_5) and 12.5 per cent potash (K_2O) and seed was sown in rows six inches apart. The crop of bulbs was riddled into four size grades and the two size grades suitable for pickling were retained for quality assessment, No. 1, 1 to just under $1\frac{3}{8}$ inches diameter ; No. 2, $1\frac{3}{8}$ to just under $1\frac{1}{2}$ inches diameter.

Owing to poor germination of the seed of the variety New Brown Pickling (Thoday's) its yield results could not be compared with those of the other varieties, germination of which did not differ from one another. The yields of Giant Zittau, German Pickler (Thoday's) and Rijnsburger did not differ significantly from each other. In general, sowing rates of 20 and 30 lb. per acre produced no significantly different effects on the yield of onions marketable as picklers, but gave significantly greater yields than that from the rate of 40 lb. per acre. The two sowing dates did not differ in their effects on yield.

Samples of No. 1 size were judged by representatives of the pickling trade, by arrangement with the British Food Manufacturing Industries Research Association. Regarding shape and texture of the raw onions, the varieties Giant Zittau, German Pickler (Thoday's) and New Brown Pickling (Thoday's) were acceptable for pickling ; Rijnsburger was acceptable for texture but not for shape. The different sowing rates and sowing dates produced no significantly different effects on shape or texture. Pickling tests on the samples are being made.

Onion sets. The effect of onion set size and overwinter storage temperature on the performance of four onion varieties was measured in a field experiment in 1958. The sets were grown from seed in 1957 under Dutch light frames and, after harvesting and drying the sets, they were graded into two sizes (less than 2 gm. and 2-4 gm.). Sets were stored from October to March either in an unheated, open-sided store or in a cabinet at 20°C.

The results agreed with those of other investigators, e.g., Heath (7). Onions grown from sets stored at 20°C. were almost free from bolters and gave a significantly higher yield of marketable onions at harvest than those grown from sets kept over winter in an open-sided store. Large sets gave up to 30 per cent of bolters but despite this they gave significantly greater yields of marketable onions than the small sets, even although the latter contained a negligible percentage of bolters.

On harvesting, Cambridge No. 10 gave a heavier yield of marketable onions than Stuttgarter Riesen and Big Ben but after storage for two months the bulb losses with Cambridge No. 10 amounted to 77 per cent as compared with 50 per cent for the other two varieties. In consequence, Stuttgarter Riesen and Big Ben, which are regarded as standard varieties for growing from sets, gave heavier yields than Cambridge No. 10. Onions from large sets did not keep so well as onions from small sets and the best yield of onions after storage for two months was obtained from small sets which had been stored over winter at 20°C.

Environmental effects on onion seed. It is known that yield trials of onion varieties often give conflicting results and that this is caused mainly by variation in seed germination. It is suspected also that the germinative ability of the seed is associated with the conditions under which it has been produced. Starting with one lot of seed of each variety, the next generation of onion seed was produced, therefore, under all 12 combinations of the treatments listed below. Pollination was effected by blowflies in insect proof cages.

Varieties—Cambridge No. 3 and Cambridge No. 10.

Sites where bulbs were grown—Wellesbourne, Efford E.H.S. and
Stockbridge House E.H.S.

Sites where bulbs were seeded—Wellesbourne and Efford E.H.S.

Replicated laboratory germination tests on the 12 lots of seed were carried out under standard conditions (8) and mean seed weights were determined. In general, only the site of seeding the bulbs significantly affected percentage germination and mean seed weight.

Each of the 12 lots of seed was sown at three rates, 4, 8 and 12 lb. per acre, in a randomised block field experiment at Wellesbourne in 1958. The log yield was plotted against log plant density (the relation being linear over the range of densities achieved) and the slopes and intercepts of each line on the log yield axis were compared. The slopes of the lines obtained for the two varieties were different, but the lines obtained for all other treatments were not significantly different regarding slope or intercept, although mean plant density and mean yield were different as a result of difference in percentage germination of the seed. The differences in percentage germination of seed, which led to variations in yield, were found to result from the effects of the different sites where the bulbs had been seeded. The sites where the bulbs were grown did not have an ultimate effect on percentage germination of the seed.

THE PROPAGATION OF WATERCRESS FROM SEED (J. K. A. Bleasdale)

Most commercial strains of green watercress (*Nasturtium officinale* R. Br.) begin to flower during April or May, thus restricting the production of marketable cress at a time of the year when the demand is still high. Tests of the late-flowering strain of cress previously selected (4) have been begun under commercial conditions. The results so far have indicated that it cropped as well as existing commercial strains and had the advantage of a considerably extended cutting season. The leaf size during the winter was smaller than desirable but further selection for the improvement of this character has met with some success. Good seed production was obtained from this and other strains by growing plants on land during the summer months.

GIBBERELIC ACID (J. K. A. Bleasdale)

Investigations were carried out to determine whether gibberellic acid could be used profitably to induce the reproductive phase in a number of vegetables with a view to facilitating plant breeding programmes. Carrot, red beet and turnip all formed flowers earlier than the controls as a result of repeated micro-drop applications of gibberellic acid. Flowers of Brussels sprouts and cauliflower were not affected by the doses used.

The variety of carrot used, Clucas' New Model, required particularly large applications repeated over a long period before any response was obtained. Bukovac and Wittwer (5) reported induction of flowering in carrot with applications totalling 20 to 200 μ gm. per plant. The strain of New Model used at Wellesbourne needed 2,000 to 2,500 μ gm. before flowering occurred. This supported a conclusion arrived at from a study of the literature, namely that varieties of a species are liable to differ in their dose response to gibberellic acid. Other evidence, and the results obtained at Wellesbourne, indicated that the flowering response to gibberellic acid depended largely on the temperature and photoperiod used being very close to those known to induce flowering of

their own accord. In view of this there would appear to be little advantage to be gained by using gibberellic acid to control the flowering in the majority of vegetables.

Single applications of gibberellic acid to roots of rhubarb, variety Prince Albert, placed in the dark at 55°F. caused bud break and petiole elongation although the roots had not received sufficient cold to break dormancy in response to increased temperature. The doses used ranged from 125 to 2,000 μ gm. per plant. The higher the dose applied the more vigorous and prolonged was the growth obtained but the highest doses used failed to induce growth equivalent to that of plants which had received an adequate cold stimulus. Low doses resulted in a slight and temporary breaking of dormancy. Seakale crowns responded in a similar manner to rhubarb.

Rhubarb, variety Prince Albert, when forced under normal conditions, did not respond to twice-weekly sprays of gibberellic acid (100 p.p.m.) ; neither the total weight of sticks, the weight of marketable sticks, the number of sticks, nor the length of sticks differed significantly from the controls.

FLOWERING OF RED BEET (R. Prieto-Ruiz)

Roots of red beet, variety Detroit Red Globe, were lifted from the field at the end of August 1957. The roots were then stored for periods ranging from 4-10 weeks at three temperatures (4, 10 and 15°C.). Subsequently the roots were grown in a glass-house (diurnal cycling temperatures 13-24°C.) in either a 12 or a 16 hour daylength. Some plants received applications of gibberellic acid.

Records were made of the incidence and rate of bolting. Detailed analysis of the data has not yet been made, although it can be seen that an increased rate and amount of bolting resulted from the following treatments either separately or combined :— cold storage (4 and 10°C.), long photoperiod, and gibberellic acid.

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IRRIGATION REPORT

By E. J. WINTER

Although soil moisture deficits at Wellesbourne were 1.0 and 1.5 inches at the end of April and of May 1958 respectively, rainfall during the summer was such that irrigation of unprotected experiments generally produced adverse effects. Fortunately, however, a new set of permanent plot shelters had been built early in 1958, and these made it possible to carry out satisfactorily a number of irrigation experiments even in this very wet season.

The design of these shelters was based on that of previous temporary shelters (6) but the channel girders forming the rails and gutters were mounted on brick piers. The new shelters enabled any part of an area of about $\frac{1}{2}$ acre to be protected from rain.

The irrigation indicator described elsewhere (4) is now being manufactured and sold by a commercial firm.

Mr. D. H. Drew joined the Section in August 1958 as successor to Dr. Stanhill and began an investigation into the functioning of root systems of vegetables, especially in regard to the uptake of water and nutrients.

IRRIGATION OF CAULIFLOWERS (P. J. Salter)

It was found previously (3) that dry soil conditions during the propagating stage of autumn-sown, early summer cauliflower plants of variety Finney's 110 caused the plants to produce smaller, earlier curds and a greater number of 'buttons' than plants kept moist during the propagating stage. The experiment was repeated during the season 1957-58 using two varieties of early summer cauliflower, Finney's 110 and Remme. Young plants growing in 3-inch pots in unheated frames were subjected either to wet or to dry soil moisture treatments from 1st November 1957 until 1st April 1958 when they were planted in the field. Under the wet treatment the plants were watered every other day; with the dry treatment the soil was allowed to dry almost to the wilting point before being watered. No attempt was made to apply measured quantities of water, but the soil in the pots was restored to field capacity at each watering. After planting in the field, half of each batch of plants was irrigated whenever the available water in the root zone had been depleted by 25 per cent, sufficient water then being given to restore the soil to field capacity. The other half of each batch received no water other than rainfall.

Wet weather after planting caused the soil moisture conditions to become almost the same in the two field treatments, and plant responses to these treatments were not significantly different. With the variety Finney's 110, however, dry conditions in the propagating stage resulted in the curds being significantly smaller at harvest and maturing about seven days earlier than those of plants given the dry treatment. With the variety Remme, the different watering treatments during the propagating stage did not affect curd size or earliness. No buttoned plants were produced in this experiment.

The results with variety Finney's 110 support the previous year's results. Variety Remme had not been used previously in this work and it is interesting to note the apparent variety difference in response to different watering treatments.

GROWTH STUDIES ON CAULIFLOWER (P. J. Salter)

Study of the growth and development of the early summer cauliflower plant was continued in 1958 to provide further information as a basis for experimental work on the water relations of this crop. At weekly intervals, from the time of seed sowing in October 1957 until seed harvest in August 1958, samples of 10-40 plants were taken

from a population growing in the field. The growth rate of roots, stem, leaves and curd was measured in terms of increase in fresh weight, dry weight, and linear dimensions.

It has been stated that when the weather is changeable the use of days as an independent variable against which to plot growth gives a misleading picture of the shape of the growth curve (1). Various other 'time scales' have been tried including accumulated day-degrees above a base temperature of 42°F., incoming radiation (gram-calories), day-degrees x day-length, calculated evapo-transpiration, and evaporation from an open water surface.

Using accumulated day-degrees above 42°F. as the time scale, the form of the growth curve of the cauliflower plant (total dry weight) was exponential from the pricking-off stage until the curd was mature, a period of almost nine months. After the curd was mature the growth rate became progressively lower until flowering time, after which a reduction in total dry weight occurred, followed by senescence, seeding and death. When the previous year's data were plotted on the same time scale, the growth curve for the whole plant was again exponential and the linear regressions of growth (in terms of log. dry weight) on accumulated day-degrees for the two years were not significantly different. The use of the other four time scales did not give exponential growth curves and did not account for as much of the variance as did accumulated day-degrees. Moreover, on plotting the growth of the curd during 1957 and 1958 against accumulated day-degrees, a curve closely fitting a Gompertz equation was obtained for each year's data, whereas the other four time scales again gave dissimilar curves.

These results suggest that the growth of cauliflower plants and of their curds during different years may be compared more accurately by using a time scale based on accumulated day-degrees than with other time scales. They also indicate that, under the conditions of these experiments, temperature was the major factor influencing growth when soil moisture and nutrient status were made non-limiting. This work is being continued.

IRRIGATION OF SUMMER LETTUCE (P. J. Salter)

Previous work on the irrigation of summer lettuce at Wellesbourne has given conflicting results. Winter found that heavy watering in the seedling stage appeared to reduce ultimate yield (5) and in another experiment the highest yields were obtained by watering up to but not after the beginning of hearting (6). Salter, however, found that continuously moist soil conditions from planting time until harvesting increased the head weight and reduced the numbers of unmarketable heads (2).

Two experiments on the irrigation of summer lettuce were successfully completed in 1958, despite the wet weather, by protecting the plots from rain (6). One was designed to compare the effects of treatments based on the percentage depletion of available soil water in the root zone (25, 50 and 75 per cent depletion) with those of treatments based on total soil moisture deficit ($\frac{1}{2}$, 1 and $1\frac{1}{2}$ inches maximum permitted deficit). Under treatments on the former basis the plants were subjected to approximately the same maximum moisture stress throughout their life, because account was taken of their depth of rooting in computing the quantity of available water. Under treatments on the latter basis, however, the soil moisture stress imposed on the plants varied according to the rate at which their roots were able to extend into hitherto unexploited soil.

The results indicated that the yield of lettuce was adversely affected by depletion of more than 25 per cent of the available water in the root zone. In the early stages of growth a half-inch deficit (at this time equivalent to more than 25 per cent depletion of available water) was found to reduce growth rate. The mean weight per head at harvest, and the number of marketable heads were both reduced by the accumulation of more than a half-inch deficit at any time during growth. These results confirmed previous findings by Salter (2).

In the second experiment, lettuce plants were irrigated at different stages of development, the water being applied as a mist except for one treatment where it was

applied in the usual manner as a spray. The speed of deposition of water was approximately the same with both methods of application. The mist application resulted in the plants maturing earlier and with less damage from *Botrytis*, and they consequently yielded a larger number of marketable heads than those irrigated with the spray. This result suggests that the depression in yield sometimes observed following the irrigation of lettuce (5) may have been caused by unsuitable methods of applying the water.

IRRIGATION OF A ROTATION OF CROPS

(E. J. Winter and F. Lucy C. Blackwall)

The long-term experiments on the irrigation of various crops at the N.A.A.S. Experimental Horticulture Stations (7) were continued. These large experiments were not protected from rain which, in 1958, seriously interfered with the irrigation treatments.

At Luddington in 1958, restoration of the soil moisture content to field capacity whenever the accumulated deficit amounted to half-inch resulted in statistically significant depressions in yield of early summer cauliflower (13 per cent), early lettuce (19 per cent), summer lettuce (71 per cent), and carrots (36 per cent). At Efford, a similar treatment at $\frac{3}{4}$ -inch deficit resulted in a significant depression in yield of early lettuce of 18 per cent. In a warm dry season these treatments would probably have increased the yield of some at least of these crops, and it seems likely that the depressions were the result of the soil being frequently saturated, when rain followed soon after irrigation.

At Efford, irrigation at $\frac{3}{4}$ -inch deficit significantly depressed the yield of spinach by 34 per cent, but restoration to field capacity once only, after seedling emergence, significantly increased the eventual yield.

At Rosewarne, irrigation resulted in no significant differences in yield among the vegetable crops. With narcissus, however, watering during 1957 and 1958 whenever a $\frac{1}{2}$ -inch or one-inch deficit had arisen resulted in significant flower crop increases in 1958 of 29 per cent and 16 per cent (var. *Helios*) and 27 per cent and 21 per cent (var. *Boswin*), respectively. It appeared that more daughter bulbs were produced on the plots watered in 1957 than on the unwatered plots, and in the following year these daughter bulbs produced saleable flowers.

FACTORS AFFECTING THE SET OF RUNNER BEAN PODS

(F. Lucy C. Blackwall)

Growers have frequently reported heavy losses in yield of runner beans as the result of failure of the flowers to set pods, and of pre-harvest dropping of immature pods. This has been variously attributed to unfavourable weather or soil moisture conditions, and an investigation has been started with the object of determining the causes of the trouble and of devising possible remedies. A field experiment was carried out in 1958 to determine the effects of different watering treatments and of meteorological factors on pod set and marketable yield of runner beans, variety *Streamline*. The plants were grown up six-foot canes spaced two feet apart in the rows, with four feet between rows, and side shoots were removed to facilitate recording. There were 12 plants in each plot, with adequate guard rows, and the three treatments were replicated five times in randomised blocks.

Treatments :

- A. Control—no irrigation or spraying.
- B. The soil was restored, by low-level watering, to field capacity whenever the accumulated loss from the Agro-Met. station evaporation tank amounted to $\frac{1}{2}$ -inch since the previous watering.
- C. Same as for B, and in addition, on dry days (when the relative humidity was probably less than 75 per cent), the flowers were sprayed with a fine mist at noon and at 4 p.m.

Once each week all newly-opened flowers were counted and marked with small coloured tags. At the same time records were made of surviving developing pods marked with the different-coloured tags which had been put on in previous weeks.

Neither the number nor the weight of pods harvested was affected by the irrigation treatment or by the flower-spraying treatment. There was, however, a wide weekly variation in the percentage of flowers which set pods and a smaller variation in the percentage of young pods which abscised before harvest, and these variations did not appear to be affected by the different treatments. The data are being examined to ascertain whether there is any correlation between these variations and the variation of the different weather factors measured on the nearby Agro-Met. station.

Other experiments were carried out in the field and in the glasshouse. It was found that when the growing point was removed above the first pair of true leaves, some plants responded by producing an inflorescence instead of a shoot from each of the two leaf axils. These pairs of inflorescences of identical age formed convenient material for pollination experiments which showed that the runner bean flowers did not set pods unless they had been pollinated either by insects or by hand, and that artificial cross- and self-pollination, and pollination by insects were all equally effective ; natural self-pollination apparently did not occur. Insect pollination in the field seemed to be adequate because no increase in the number of pods set was obtained by supplementing it with artificial cross-pollination.

These investigations will be continued to ascertain whether drier seasons will give similar results to those obtained during the wet season of 1958, and whether different varieties of runner beans differ in their pollination requirements.

Acknowledgments

We wish to thank the staffs at Efford, Luddington, Rosewarne and Stockbridge Experimental Horticulture Stations of the N.A.A.S. for carrying out the irrigation experiments on a rotation of crops described above.

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ENTOMOLOGY REPORT

By D. W. WRIGHT

Research has been continued during 1958 on problems connected with control of carrot fly, cabbage root fly and lettuce root aphid. Work on the factors concerned in the natural control of the cabbage root fly, on methods of measuring the persistence of insecticides in the soil, and on the effects of insecticides on various soil insects has also been expanded.

Mr. B. Mitchell of the University of Birmingham, who was awarded an Agricultural Research Council Scholarship in 1956, continued research for a second year at Wellesbourne on predators of the cabbage root fly.

THE NATURAL CONTROL OF CABBAGE ROOT FLY AT WELLESBOURNE (R. D. Hughes, Dorothy D. Salter and B. Mitchell)

Increases in the infestations of cabbage crops by cabbage root fly in the years following the use of insecticides when broadcast and worked into the soil, have made necessary fuller investigations of the biology and natural control of this pest (2, 5, 6).

Detailed census data, begun in 1957, have been obtained of root fly populations at the different stages of the life cycle in each of four successive generations. This has shown that there was about 95 per cent mortality in each generation, 90 per cent having occurred during the egg stage. These findings confirmed less complete data of previous years (Hughes and Salter, in press).

The proportion of eggs eaten by predatory beetles has been estimated by a new method, using two series of consecutive egg counts taken at different time intervals (four days and two days). The results obtained were used in conjunction with the daily records of the numbers of beetles trapped amongst the crop to calculate the numbers of eggs eaten. These calculations showed that nearly all of the 90 per cent mortality in the egg stage was caused by predators (Hughes, in press). The amount of egg predation was nearly always reduced by rain, particularly by heavy rain which broke down the soil surface structure thus covering most of the eggs and protecting them from further predation. During weather especially favourable to the predators, however, they were able to exercise almost complete control of the pest (over 98 per cent of eggs were eaten in the early part of the spring generation, 1958).

Little mortality occurred in the larval stages of the root fly except when high numbers of larvae and dry soil conditions brought about premature death of the plant. In these circumstances the young larvae died and the older larvae pupated prematurely but they did not usually develop into adult flies. In the pupal stage, mortalities of up to 65 per cent were recorded, and this was mainly the result of parasitism by *Idiomorpha rapae* (Hymenoptera, Cynipidae) and *Aleochara* spp. (Coleoptera, Staphylinidae). Adult mortality was usually low until after the first batch of eggs had been laid.

The usual number of eggs laid by each female was greatest (approximately 80) in the adult population emerging from over-wintering pupae, and was much less in later generations. A lower mortality in the immature stages of the second generation compensated for this decreased fecundity, and the average number of larvae per plant in each generation did not vary greatly for one type of crop. With Primo cabbage, the average number of larvae per plant was about 25, and these caused only a small percentage of plant deaths. In the spring of 1957, however, the larval numbers averaged about 38 per plant, and in that crop 34 per cent of the plants were killed.

When soil insecticides are used, the egg predation by the beetles is reduced. Even a small decrease in predation (10 per cent) will result in the doubling of the number of eggs which hatch, so that when insecticides are present at a dosage rate which is too low to affect the larvae of the pest but will still affect the predatory beetles, higher infestations than those under natural control are likely to occur—as observed in 1955, 1957 and 1958.

THE CONTROL OF CARROT FLY (D. W. Wright)

Certain insecticides have been shown to be highly effective for the control of carrot fly when incorporated into the soil before sowing. Various methods by which these may be applied and mixed with the soil have been compared in experiments carried out in 1958 on fen soil at Chatteris. In one of these, dieldrin was mixed with the soil to different depths and, after preparation of a seed-bed, each plot was sown with early and maincrop carrots. The carrot fly infestations on the various treatments are shown in the table.

**Effect of depth of incorporation of insecticide
into the soil on the level of carrot fly control—
Chatteris 1958**
Per cent of roots attacked

Dieldrin lb./acre	1	1	1	1	1½	0
Depth of incorporation of insecticide	1"	2"	3"	4"	4"	—
Early carrots	81.3	12.7	3.7	1.7	2.0	95.0
	L.S.D. (P=0.05) ± 1.77					
Maincrop carrots	27.7	10.3	10.3	5.3	1.0	70.7
	L.S.D. (P=0.05) ± 2.81					

Insecticide was incorporated in the soil by rotavating twice, except at the one inch depth where it was done by raking twice. The control plots were also rotavated twice.

The results showed that the effectiveness of the insecticide increased with its depth of incorporation in the soil and that the shallowest soil treatment was comparatively ineffective. This confirmed results obtained in 1957 and indicated that incorporation in the top four inches of soil was necessary for the most complete control.

The effects of different methods of incorporating insecticide in the soil and of different degrees of their mixing, on the level of carrot fly control was investigated in other experiments. Using the same amounts of dieldrin, one rotavation of the soil resulted in a less complete control of the pest than where two rotavations were used, but three rotavations did not result in any further improvement. Hand-digging of the soil twice, each time to a depth of four inches, resulted in a very high level of carrot fly control. In a field trial, strips of land sprayed with dieldrin and then disced twice to a depth of four inches, followed by harrowing and consolidation to form a seed-bed, also gave a very satisfactory control of the pest.

In experiments carried out over the period 1955–57 the insecticides have been applied to the soil, prior to incorporation in it, as a low percentage dust mixture. As this method of application cannot be readily mechanised for field use, experiments were carried out in 1958 to compare the effectiveness of an insecticide applied as a dust with that applied as a liquid spray. Using the same dosage rates of dieldrin, application as a spray at the rate of 50 gallons per acre and as a dust gave similar levels of carrot fly control. Furthermore, dieldrin applied in water either as an emulsion or as a suspension and rotavated into the soil, gave very similar levels of pest control.

Experiments have been continued to determine the minimum dosage rates of aldrin and dieldrin which, when worked into the top four inches of soil, will give a satisfactory control of carrot fly on medium loam at Wellesbourne and on fen soil at Chatteris. At

Wellesbourne, aldrin used at the rate of 1 lb. per acre gave a minimum of 97 per cent control of the pest on carrots in 1957 and 1958 ; when used at $\frac{3}{4}$ lb. per acre, however, the control was much less complete. In 1958, dieldrin at $\frac{1}{2}$ lb. per acre gave a complete control of a moderate carrot fly infestation (average root attack on untreated plots was 52 per cent). Evidence was obtained, however, that the effectiveness of soil insecticides was enhanced by the cool, moist soil conditions in 1958 and data obtained in the previous year indicated that $\frac{3}{4}$ lb. per acre of dieldrin was required to give satisfactory control in a drier and more normal season. With fen soils, a much higher dosage rate of both aldrin and dieldrin was required than at Wellesbourne. Dieldrin at the rate of $1\frac{1}{2}$ lb. per acre has consistently given an almost complete control of severe carrot fly infestations. Similar results have been obtained with aldrin but the rate necessary to achieve this was 4 lb. of the insecticide per acre.

Tasting tests have been carried out on samples of carrots grown in soil treated with these insecticides. They have shown that no taints or marked loss of flavour to carrots resulted from the use of either aldrin or dieldrin in the soil at Wellesbourne at rates of up to 2 lb. per acre. The same rate of dieldrin in fen soil similarly produced little or no effect on flavour but aldrin at 4 lb. per acre on this soil caused marked loss of carrot flavour.

When either aldrin or dieldrin is used in the soil the rates of application should be the minimum consistent with obtaining a high level of pest control.

CARROT FLY ON PARSNIPS (G. A. Wheatley and J. A. Hardman)

Observations on the biology of the carrot fly, *Psila rosae* F., were continued at Wellesbourne, and parsnips were examined each week from mid-July 1957 until early February 1958. It was confirmed that mines caused by the first generation larvae healed rapidly during August and later became indistinct (3, 4). A steady increase in mining by second generation larvae was noted throughout the autumn and winter. This was in contrast to observations made in 1954, 1955 and 1956 when a sudden increase in mining marked the onset of second generation attack. The infestation on parsnips during 1957-58 was less than in previous years and it was estimated that the population of carrot fly in the experimental area only about half that normally present.

A detailed study was made in 1957 of the distribution of carrot fly attack on a plot, 12 yd. $\times$ 16 yd., in which the amount of damage on each root and its position in the plot were recorded. It was found that the carrot fly larvae tended to attack along the length of the rows but that the infestations on adjacent rows were independent of one another ($P=0.05$). This result suggested that, in field experiments with carrot fly, plots should be orientated with their long axes across the rows and that samples of roots should be taken from short lengths of a large number of rows rather than from long lengths of a small number of rows.

Field experiments were carried out with dieldrin and gamma BHC to determine if their efficiencies as seed dressings were affected by different methods of mixing insecticide, sticker and seed. With both insecticides all the methods of dressing the seed used gave very similar levels of carrot fly control. Dressed seed sown at the beginning of April suffered a prolonged drought, and germination was delayed for several weeks. Under these conditions the gamma BHC seed dressings proved to be phytotoxic and reduced germination by 90 per cent as compared with untreated seed. The dieldrin seed dressings reduced germination by about 50 per cent but a sufficient number of seedlings germinated to enable a full stand of plants to be obtained after singling. Another sowing of dressed seed was carried out at a later date but rain fell within a day of sowing and only a very slight reduction in germination was noted. It was also found that, when the crop was irrigated at frequent intervals up to the time the seedlings appeared, the efficiency of the seed dressings for carrot fly control was slightly reduced. These experiments suggest that seed dressings containing gamma BHC and dieldrin, which are normally quite safe, may prove phytotoxic if a drought persists for some weeks after sowing. Dieldrin is apparently much safer in this respect and should be used in preference to gamma BHC for dressing parsnip seed.

A $2 \times 4 \times 2$ factorial experiment was also carried out in 1957 to compare the efficiency of dieldrin applied as a seed dressing, as a band spray applied to the seedlings before and after singling, and as a spray applied to the crowns of the roots early in August. These treatments were applied singly and in all combinations. Although the results were difficult to interpret, because of the light, patchy infestation on the experimental area during 1957, it was again clear that little could be gained by applying a multiplicity of treatments of this type to the same crop. Even when applied in combination with each other, these methods of treatment gave an incomplete control of carrot fly and it is thought that this was the result of a maldistribution of insecticide rather than to any exceptional resistance on the part of the insects which survived. Comparable quantities of dieldrin to those used in these treatments can be broadcast and worked into the top few inches of soil and, when applied thus, dieldrin will give an almost complete control of the pest. It is clear that the insecticide is being used in a much more efficient manner when it is broadcast on the soil. Further improvements in control measures for carrot fly seem more likely to result from the broadcasting and mixing of insecticide with the soil than from the use of seed dressings and sprays applied to the crop, and work on these latter methods has been discontinued.

LETTUCE ROOT APHID (J. A. Dunn)

In 1958 the aphid populations on the roots of summer lettuce at Wellesbourne were lower than in any of the four previous seasons. However, despite the low numbers, certain insecticide treatments gave high levels of aphid control. Endrin seed dressing alone failed to control the root aphid but when this treatment was supplemented by a 0.2 per cent spray of either endrin or diazinon, applied along the rows just after singling, more than 95 per cent reduction in aphid numbers was obtained. Similarly, endrin dust, or emulsion, and diazinon emulsion (4 lb. of actual insecticide per acre) applied to the soil just before sowing and rotavated into the top three inches, all gave more than 95 per cent control of root aphid. Diazinon seed dressing (10 per cent by weight of diazinon to seed) alone, or supplemented by a 0.2 per cent diazinon spray applied to the rows just after singling, failed to give satisfactory control.

A technique has been developed for testing resistance to root aphid in the progeny of crosses made between resistant and susceptible varieties of lettuce. The plants are subjected to a uniform and intense attack by the aphid under glasshouse conditions, and the amount of colonisation occurring on each plant is used as a measure of its resistance to the aphid. Tests carried out in the field have proved unsatisfactory because of considerable local and annual variation in the aphid numbers.

The subject of alternative secondary host plants of lettuce root aphid has been investigated further. The following weeds, all members of the Compositae sub-family Liguliflorae and occurring in the Wellesbourne area, have been found to be hosts of the aphid:— *Sonchus asper*, *S. arvensis*, *S. oleraceus*, *Hypochaeris radicata*, *Tragopogon pratensis* and Dandelion. Other members of the same sub-family found not to be hosts were:— *Crepis taraxacifolia*, *Leontodon autumnalis*, *L. leysseri* and *Picris echinoides*.

PEA MOTH (J. A. Dunn and G. A. Wheatley)

Freshly formed pea moth cocoons were again collected at the end of August 1957 from peas grown at Wellesbourne. The cocoons were subjected to various constant temperature treatments in the laboratory in order to obtain further information on the temperature requirements necessary for the completion of the diapause development in the over-wintering pea moth larvae. The results, together with those obtained previously, showed that diapause did not end suddenly but gradually decreased in intensity at a rate dependent on the prevailing temperatures. The time required to complete subsequent morphogenesis, at any given temperature, was also affected by the temperature prevailing during diapause.

These findings indicate that there is considerable seasonal variation in the number of day-degrees needed for the insect to complete development in spring, and that the

requirements may differ from site to site. Where annual temperature changes are not regular, as in Britain, it would be very difficult to devise a practical day-degree method of predicting the emergence of pea moth.

A field experiment was carried out in 1958 to compare the efficiency of DDT, dieldrin and a mixture of chlorthion and dipterex for the control of pea moth. The population of the moth was extremely low; less than two per cent of the pods were attacked on the untreated peas and it was not possible to obtain information on the control. A considerable pea aphid population was present when the treatments were applied, however, and samples were taken to determine the effects of the insecticides on aphid numbers. DDT, applied as a 0.25 per cent emulsion at the rate of 50 gallons per acre, gave approximately 95 per cent reduction in aphid populations and an increase in the rate of application to 150 gallons per acre did not markedly improve the control obtained. The chlorthion-dipterex mixture (0.05 per cent of each at 50 and 150 gallons per acre) gave only moderate control of the aphid, amounting approximately to 75 per cent reduction in numbers. The dieldrin, applied at 0.1 per cent in 50 and 150 gallons per acre, gave no control and did, in fact, cause an increase in aphid numbers as a result of its adverse effect on the predators.

BIOASSAY OF INSECTICIDE RESIDUES IN SOIL AND PLANT TISSUE

(G. A. Wheatley and J. A. Hardman)

In connection with the research on control of carrot fly by means of broadcast applications of aldrin and dieldrin, it is essential that knowledge of the persistence of residues of these materials in the soil should be extended and that information should also be obtained on the residue level present in crops grown on treated soils. Work has been started, therefore, to develop suitable biological assay methods for these insecticides when present in soils and in plant tissues, using *Drosophila melanogaster* Mg. as the test insect. The work to date has been primarily concerned with adapting and developing satisfactory techniques for handling and rearing the insect, and with exploring the possible methods of assaying dieldrin residues in soils. A direct method of assay for determining residues in soils (1) has been found to be insufficiently sensitive for the highly organic fen soils and an alternative technique is being developed which, it is believed, will prove satisfactory for most soils.

Preliminary results with a mineral soil (sandy loam) at Wellesbourne have indicated that dieldrin applied to plots of soil early in 1956 at rates of 1, 2 and 3 lb. per acre was still present in July 1958 at levels of about 0.3, 1 and 2 lb. per acre, respectively. These results were confirmed by the degree of carrot fly control obtained on the plots in 1957 and 1958.(7).

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PLANT PATHOLOGY REPORT

By W. G. KEYWORTH

SILVERING DISEASE OF RED BEET (W. G. Keyworth and J. Sheila Howell)

Commercial formulations of streptomycin are now available to growers and thus the material can be used for the treatment of seed against this disease. Further tests have confirmed the continued effectiveness of the compound for this purpose. Tests of isolates of *Corynebacterium betae* obtained from occasional silvered plants occurring in crops grown from seed treated with streptomycin showed that none of the isolates was resistant to the action of the compound. The diseased plants had thus presumably grown from the few seeds that had escaped the full effect of the treatment and were not indicative of the development of streptomycin resistant strains of the pathogen. Further observations will be made on this subject.

Studies have been continued on the mode of spread of the disease.

DIDYMELLA STEM ROT OF OUTDOOR TOMATOES (R. B. Maude)

In continuation of the trials of maneb and captan for the control of the disease these compounds were applied in numerous field experiments. It was found that 0.5 per cent maneb (half the strength used previously) and 0.25 per cent captan gave good control when applied every three weeks. The quantity of spray given at each application was reduced by 2/3 to 50 ml. per plant without loss of effect.

Trials were made of the application of the fungicides by watering and admixture with peat placed around the collars of the plants, but these were not as effective as spray applications to the lower stem and stem-base.

Further attempts were made to study the effects of fungicides under conditions of natural infection but, as in previous years, it proved impossible to induce such infection even though numerous sources of spores were dispersed among the crop.

The plants of the F₁ progeny of a cross between *L. hirsutum* and *L. esculentum* variety Harbinger, produced by the Plant Breeding Section, were tested for their reaction to *Didymella* stem and root infection. Positive resistance was recorded.

PARSNIP CANKER (A. G. Channon)

Investigations on this disease have been concerned both with the black or purplish-black type of canker caused by *Itersonilia* or *Phoma* spp., and with the orange-brown type from which no pathogen has so far been obtained.

Observations were made on the development of canker on parsnips sown in March, April and June. The following effects were noted :—

Black cankers. Fewer roots were cankered and lesions were smaller on roots sown in June than on roots sown in March. These differences were recorded in both early November and January liftings. In November the lesions on the roots from the April sowing were smaller than those on the roots from the March sowing but by January this difference was much less apparent.

Orange-brown cankers. The development of these was similar to that of the black lesions, there being fewer and smaller ones on the roots from the June sowing than on those from the March sowing. Canker ratings in November on the April-sown crop were approximately intermediate between those on the March and June sowings. The orange-brown lesions on the June crop increased in number and size between November and January, but those on the March and April crops did not.

Root weight. Later sowing was associated with a reduction in crop, the average root weights in January being as follows :

March-sown 0.88 lb. ; April-sown 0.50 lb. ; June-sown 0.34 lb.

The evidence now available suggests that, in the variety Offenham, both the size and age of the roots influence the development of the black cankers. Although late-sown plants at normal spacing give a reduced crop, it is possible that this effect can be mitigated by modification of row and plant spacing to give a higher crop with less disease than that occurring in the traditionally early-sown large plants.

Experimental storing of roots has shown that black canker developed very extensively in a soil clamp ventilated with straw chimneys, and that *Botrytis* attacked roots in a straw clamp with a sod covering.

Field selections and trials of canker-resistant lines have been continued in collaboration with the Plant Breeding Section. In addition, the resistance of some of these lines to infection by the species of *Phoma* isolated from parsnips, was tested in the laboratory and found generally to be in agreement with the field assessments.

CLUBROOT OF BRASSICAS (A. G. Channon)

Two tests were made at the Luddington E.H.S. of the effect of aldrin and other compounds on clubroot of Primo cabbage when applied to the bases of the plants shortly after transplanting. In the first experiment two rates of application of aldrin were used; $\frac{1}{4}$ pint per plant at four concentrations from 0.08 to 0.27 per cent and $\frac{1}{2}$ pint per plant at half these concentrations (0.04 to 0.135 per cent). The control of the disease increased with increasing doses of chemical. At the lower concentrations there was a marked increase in the yield of cabbages compared with the untreated controls. The higher concentrations of aldrin were somewhat phytotoxic, however, and the crop was consequently reduced in weight although still greater than that from the control plots.

In the second experiment the following materials were applied as $\frac{1}{2}$ pint spot treatments: aldrin (0.04 per cent), dieldrin emulsion (0.04 per cent, 0.08 per cent, 0.16 per cent), endrin emulsion (0.04 per cent, 0.06 per cent, 0.09 per cent), P.C.N.B. wettable powder (0.75 per cent) and mercuric chloride (0.05 per cent). The dieldrin, endrin, aldrin, and P.C.N.B. were applied shortly after transplanting. The mercuric chloride was applied as a pre-planting dibble hole treatment.

Reductions in clubroot were recorded with 0.06 per cent and 0.09 per cent endrin, 0.04 per cent aldrin and 0.05 per cent mercuric chloride, and significant increases in yield were obtained from the last two treatments. The phytotoxicity of the endrin emulsion more than offset the beneficial effect of the reduction in clubroot. An interesting feature was the significantly greater yield obtained from the plants treated with P.C.N.B. than from the controls, even though the average clubroot infection was almost the same.

In a third experiment, sodium n-methyl dithiocarbamate was applied to seed-beds six weeks before sowing Primo cabbage. Four weeks after sowing, very much less clubroot was recorded on seedlings in the plots treated with a 2 per cent solution of the commercial formulation than on the controls. The disease was not eliminated, however, and by the seventh week clubbing had appeared on some plants in the treated plots.

LEAF AND POD SPOT OF PEAS (R. B. Maude)

Further studies have been made of field outbreaks arising from infected seed and other sources, and of the spread of the disease in field plots. Tests of fungicides in the laboratory and on plants grown in the glasshouse and in the field showed that some reduction in disease was obtained by applications of thiram, captan, 'Phelam' and 'Cyprex' but the large numbers of treatments required make them of doubtful commercial value. Observations have been continued on the effects of the heat treatment of infected seed by various means.

BIG VEIN DISEASE OF LETTUCE (J. A. Tomlinson and Bridget R. Smith)

Big vein disease of lettuce, identified in crops in 1957 in Surrey and Lancashire (5), was also identified experimentally in 1958 in specimens received from Yorkshire,

Suffolk and Dorset. Reports of its occurrence were also received from Wiltshire and near Bristol and it is clear that the disease is widespread in England.

It recurred in summer and winter crops in the field and in heated and cold glass-house crops. The symptoms were variable. Thus, cabbage lettuce received in the spring of 1958 from a cold glasshouse crop showed a severe 'savoying' of the veins without the vein-banding.

To study the host range of big vein, sap from infected lettuce roots was watered on to various plant species grown in pots of soil. Big vein symptoms subsequently developed on *Lactuca dregeana*, *L. saligna*, *L. altaica* and *Sonchus asper*. Only indistinct symptoms developed on *S. oleraceus* while *L. sagittata* remained symptomless but the root sap of the inoculated plants of both species was infective to Lobjoits Green Cos Lettuce.

Studies were made on the cause of the disease. Tobacco necrosis virus was, as in 1957, frequently isolated from the roots of affected plants but further attempts to establish a relationship between the virus and the disease were unsuccessful. Experiments were made on the infectious sap from diseased root systems. If centrifuged at 3,000 r.p.m. for 3 minutes, the infectious agent was sedimented into the residue leaving a non-infectious supernatant. In other tests the sap was made non-infectious if heated to 50°C. for 15 minutes or if diluted to 1/1,000.

Workers in California (3) and New Zealand (2) have recently described the occurrence of *Olpidium brassicae* in the roots of lettuce affected by big vein and they reported experiments which strongly suggested that the disease was caused by this fungus. A similar fungus was found in England in the roots of infected lettuce plants from the field and in the roots of plants to which the disease had been transmitted in our experiments.

POWDERY MILDEW DISEASES (J. A. Tomlinson and M. J. W. Webb)

Research on this group of diseases was begun in 1957 to determine the effects on them of soil applications of zinc. The work was started to extend the findings of Bolle-Jones and Hinton (1) who demonstrated that the zinc status of the rubber plant influenced its susceptibility to mildew (*Oidium heveae*). Studies were first made on the powdery mildews of turnip and cabbage caused by *Erysiphe polygoni* DC. The plants were grown in a glasshouse in pots of soil containing various proportions of zinc-fritted glass (4) or watered with solutions of zinc sulphate. The results (6) showed that considerable control of infection was obtained when the soil contained 1 per cent w/w frit or when it was watered with solutions of zinc sulphate containing 500 p.p.m. zinc.

The zinc contents of the leaf fresh-matter of untreated turnips and turnips grown in soil containing 1.0 per cent zinc frit were 2 and 22 p.p.m. respectively, suggesting that the suppression of mildew resulted from the absorption of zinc by the plant from the soil and the accumulation of the metal in the leaves. Similar results were obtained with cabbage mildew.

Treatment of the soil with zinc frit and zinc sulphate resulted in the accumulation of zinc in the leaves of cucumber and vegetable marrow. This caused no significant reduction, however, in their susceptibility to infection by *E. cichoracearum* DC.

Further studies are in progress on the mechanism of action of zinc and on the effects of other metals.

RHIZOCTONIA DAMPING OFF AND WIRESTEM OF BRASSICAS (W. G. Keyworth)

Following severe attacks of this disease in brassica seed-beds at the Station, tests were made in the glasshouse and in frames of the effectiveness of pentachloronitrobenzene (P.C.N.B., Quintazene) for the control of the disease.

'Botrilex', a 20 per cent powder formulation of the compound, was mixed with the top soil to a depth of about one inch at a rate of $\frac{1}{2}$ - 1 oz. per sq. yd., or a 75 per cent wettable powder suspension ($\frac{1}{8}$ - $\frac{1}{4}$ oz. per gallon per sq. yd.) was watered on to the soil before sowing. The control of the disease was very considerable and of the

same order as that obtained by watering the soil with 1 gallon per sq. yd. of a 1/2,000 solution of mercuric chloride. In view of the human toxicity of the latter compound and its occasional stunting effect on the plants, the treatment with P.C.N.B. (which is non-toxic) would appear to be more suitable for commercial use.

Acknowledgments

Considerable help has been received throughout the year from growers, officers of the N.A.A.S. and firms who have supplied materials for test, to whom thanks are given. Grateful acknowledgment is also made of the help given by Dr. R. A. Shooter of St. Bartholomew's Hospital, London, in the studies of the reaction of *Corynebacterium betae* to streptomycin.

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WEED INVESTIGATIONS

By H. A. ROBERTS

ECOLOGY (Marion E. Smart, Sheelagh M. S. Hird and H. A. Roberts)

Work on the estimation of changes in the numbers of viable weed seeds present in the soil on plots of the long-term field experiments maintained by the Chemistry Section was concentrated on the Cultivation experiment (2). By the autumn of 1956, at the end of the first three-year cycle of the rotation, the average number of weed seeds in the top six inches of soil had been reduced from the original level of 163.3 millions per acre to 25.6 millions per acre. Some species, such as orache (*Atriplex patula*) and wall speedwell (*Veronica arvensis*), were represented by numbers equivalent to only five per cent of the original number, whereas the numbers of seeds of other species had suffered less drastic reduction.

The most marked differential effect of the basic cultivation treatments was that considerably greater numbers of seeds of annual meadow grass (*Poa annua*) were found on the plots receiving rotary tillage than on those which had been ploughed. Records of the weed vegetation actually appearing on the plots in 1957 showed that in addition to annual meadow grass, the numbers of plants of groundsel (*Senecio vulgaris*), chickweed (*Stellaria media*), shepherd's purse (*Capsella bursa-pastoris*) and Buxbaum's speedwell (*Veronica persica*) were also greater on the rotary cultivated plots than on those which had been deep ploughed, shallow ploughed or shallow ploughed and sub-soiled. The results from samples taken from the cultivation experiments sponsored by the N.I.A.E. at Efford, Luddington and Stockbridge House E.H.S. were in agreement with those from Wellesbourne in that greater numbers of seeds of annual meadow grass and certain other species were found on plots that had received rotary cultivation compared with those which had been ploughed.

Two field experiments were carried out to determine the effect of seedbed conditions on weed emergence and observations were made on the depths from which seedlings of various weed species can appear. Further tests on seed viability at different stages of maturity were made and experiments on seed dormancy under field conditions continued.

CHEMICAL CONTROL (H. A. Roberts)

Field trials were again carried out with runner beans and dwarf French beans in which dinoseb (amine) was used as a residual pre-emergence herbicide. The effect of rates of application of 3 and 6 lb. of actual dinoseb per acre was investigated in comparison with clean-weeded and inter-row cultivated control treatments. The degree of weed control obtained was very satisfactory, with almost complete control of annual broad-leaved weeds and appreciable control of annual meadow grass lasting for a period of five or six weeks. The rainfall at the time these trials were carried out was heavy, and in one instance more than one inch fell within 24 hours of spraying. Under these extreme conditions, some effects of the herbicide on the crop were noted. Where 6 lb. per acre had been applied, there was delayed germination, slower early growth and some depression of yield. Where only 3 lb. per acre had been applied, these effects were less marked and the yield was usually not significantly lower than that from plots which had been kept free from weeds by hand weeding. On all the sprayed plots the yield was greater than that on the control plots which had received inter-row cultivation only. An experiment at Efford E.H.S. with runner beans gave excellent results, with complete control of annual weeds and no adverse effect on crop yield or quality. It would appear from all the experimental results to date that dinoseb (amine) applied at the rate of 3 lb. dinoseb per acre is a useful residual pre-emergence treatment for runner and dwarf French beans.

In experiments with spring-sown broad beans at Wellesbourne, Efford and Luddington, dinoseb (amine) also gave good results as a pre-emergence spray. During

the early part of the year, however, the weeds often tend to emerge over a long period rather than in a flush, and a herbicide with greater persistence in the soil would be desirable. Post-emergence applications of dinoseb (amine) at 1 and 2 lb. per acre also gave good control of broad-leaved weeds, with only temporary scorch of the crop and no adverse effect on yield. There was again a tendency for further weeds to appear after the spraying had been carried out. In a trial with spring-sown field beans, simazine was used as a residual pre-emergence treatment. On the relatively light soil at Wellesbourne rates of 1 lb. per acre and above resulted in significant reductions in crop growth, but at the lower rates of $\frac{1}{2}$ and $\frac{3}{4}$ lb. per acre, good weed control with no crop damage was obtained.

The experiments with monuron for the control of annual weeds in established asparagus have now been terminated and an account of the work was presented to the Fourth British Weed Control Conference. This method of weed control has been accepted by asparagus growers, with generally satisfactory results and appreciable saving in labour costs. Work with simazine as an alternative to monuron for this purpose is being continued. In an experiment on an asparagus seedbed with monuron and simazine, very heavy rain occurred shortly after the crop had emerged and damage was produced by lower rates of application than in previous years. Monuron at 1 lb. per acre, however, caused only a temporary check to the crop and there was no significant effect on either number of plants or on crown weight at the end of the season. At equivalent rates, simazine caused greater crop damage than did monuron.

A series of tests was carried out to determine the potentialities of ethylene dipyridylium dibromide (1) for selective weed control in vegetable crops. In post-emergence applications on thirteen crops each at several different stages of growth, this herbicide proved to be extremely phytotoxic, even at rates as low as $\frac{1}{2}$ lb. per acre. Peas, broad beans, field beans and onions were the most tolerant of the crops tested, but it appeared that the degree of selectivity was insufficient to justify further work. Ethylene dipyridylium dibromide did appear to be very promising, however, as a contact pre-emergence herbicide. Tests were carried out on eleven crops and no damage was observed even when the sprays were applied immediately before emergence. Striking differences were found in weed susceptibility to this material. Chickweed, pennycress (*Thlaspi arvense*) and several other species were readily killed in the seedling stage by $\frac{1}{2}$ or 1 lb. per acre, whereas poppies (*Papaver dubium* and *P. rhoeas*) sprayed in the two leaf stage were not affected by 3 lb. per acre. The addition of a suitable wetting agent greatly improved the effect on these and other species.

A further experiment with sodium monochloroacetate as a selective post-emergence spray on drilled spring cabbage confirmed the value of this material for the control of chickweed and other broad-leaved weeds. When applied at 20 lb. per acre, no crop damage was caused other than slight scorch, provided that the crop had reached the three true leaf stage. Two trials were carried out in which simazine was applied as a residual pre-emergence treatment on direct-sown sweet corn. At rates of from 1 to 3 lb. per acre, complete control of annual weeds was obtained throughout the period of the experiments, and there was no adverse effect on crop growth, maturity or number and weight of marketable ears. As simazine is known to be very persistent in the soil, it is necessary that more information about its rate of disappearance should be gained before recommendations for use on sweet corn can be made.

The results from a trial on the eradication of horseradish at Stockbridge House E.H.S. indicated that good control had been achieved with 2,4-D and 2,4,5-T, whilst rotary cultivation also proved effective. This work is now being continued by the E.H.S. Two trials with residual herbicides for weed control in rhubarb were carried out in co-operation with the N.A.A.S. and several herbicides of this type were included in field trials with various crops at Wellesbourne.

SPRAY DRIFT (J. M. Way)

In recent years, the damage to horticultural crops resulting from the drift of synthetic growth-regulator herbicides used on cereal fields has been causing increasing concern amongst growers and other interested parties. Lack of information about

the precise morphological effects of such herbicides on horticultural crops has often proved to be a major obstacle in deciding whether observed injury symptoms have been caused by herbicide drift or by some other factor. With the support of an A.R.C. grant, a programme of work has been started which has the primary object of defining more closely the types of damage resulting from the treatment of outdoor vegetable crops with sub-lethal doses of growth-regulator herbicides such as MCPA and 2,4-D.

The symptoms of injury fall into two distinct groups (3). First, there are initial epinastic responses which may appear in a matter of hours but are usually of short duration, and second, there are formative effects on the developing tissues. The formative effects may result in the production of abnormal leaves, production of adventitious roots or proliferation of unorganised tissues, and may not be apparent until some time after the herbicide has reached the plant.

Both types of response have been studied in exploratory experiments with lettuce and other vegetable crops treated at different stages of growth with MCPA (sodium salt) at rates of from 0.001 to 0.05 lb. acid-equivalent per acre. With lettuce, even the lowest rate resulted in slight epinasty, and in the range of from 0.005 to 0.01 lb. per acre, characteristic formative effects on the leaves developed. At rates above 0.01 lb. per acre a different and more severe type of damage was observed.

It will be necessary to compare the initial development and subsequent expression of symptoms with those resulting from other agencies, such as virus or fungal attack and nutritional disorders. Attention will also be given to the possibility of relating the degree of injury to subsequent marketability, and to the factors affecting the recovery of plants which have been damaged.

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STATISTICS REPORT

By J. A. NELDER

The work of the Section was considerably hampered by failure to fill the vacant post on the scientific staff ; unavoidably, therefore, work on some projects had to be curtailed or temporarily stopped. Queries and requests for advice from other Sections of the Station were not less numerous, however, and covered a variety of subjects from sampling techniques for assessing disease to the use of spherical trigonometry for evaluating the amount of sunlight falling on a crop at different times of year.

Mention was made in the Eighth Annual Report of work in progress on the use of various meteorological quantities to replace time as the independent variable in growth equations. To provide more data for this study an experiment was carried out tracing the growth of carrots sown at four different dates during the spring and summer. Root and top weights were taken at frequent intervals for the construction of growth curves, but the uniformly sunless and cool conditions prevailing almost throughout the summer made 1958 a poor year for discriminating between different time scales. Various theoretical models for the joint growth of tops and roots in carrots have been formulated and their consequences elucidated, and one has been shown to give results in general agreement with field data over a considerable part of the growing season. More data are needed to show whether such models can be used to give useful predictions testable in actual experiments.

Experimental technique

Another experiment to test the effect of early weeding and seed-chitting on the variability of red beet was carried out during the year. Half the seed was set to chit at the same time as the other half was sown, and the chitted seed was sown six days later. These two treatments were combined factorially in a replicated experiment with two weeding treatments, a normal and an intensive treatment which principally differed from the normal in having the first weeding eight days earlier. Chitting did not affect the yield in 1958, probably because there was abundant moisture in the field. Intensive weeding, however, increased the marketable yield by 15 per cent and also reduced the variance, the net result being that five replicates of the intensively weeded plots gave an accuracy equivalent to nine replicates of the normally weeded plots. (As before accuracy was measured in terms of percentage standard error). This confirmed the result of the previous year and showed that intensive weeding can give substantial improvements in accuracy in experiments on red beet.

A similar type of experiment was carried out on onions, using two weeding treatments and two seed rates. The amount of weed was unusually small in this experiment, and although a small increase in yield (amounting to eight per cent) was found in the intensively weeded plots there was no significant effect on variability. Both seed rates gave stands sufficiently close to the optimum for there to be little difference in mean or variability.

Biometrical genetics

In experiments on the inheritance of quantitative characters, estimates of variance components have hitherto been obtained by using a least-squares method in which the information supplied by the different generations has been taken to be equal and independent. In practice this is not so and the possibility arises, therefore, of improving the accuracy of estimation by weighting the different generations according to their informativeness. Expressions for the optimum weights have been worked out for various theoretical systems of inheritance, and the adequacy of a simplified method suitable for use in practice has been tested and found satisfactory. The theoretical results obtained and the results of their application to some actual data have been described (1).

A further field experiment with French beans has been carried out, using a diallel cross of six varieties together with all the F_2 's. Data on flowering time and seed size and shape have been collected and the adequacy of existing theoretical models for these data is being tested.

Work for other bodies

J. A. Nelder continued to serve on the Glasshouse and Protected Cropping Working Parties of the A.I.C.'s Experimental Horticulture Committee, and also served on the N.A.A.S. Vining Pea Group. During the year 68 experiments were analysed for outside bodies, involving 3,300 plots and an average of 3.2 variates analysed for each experiment ; this represents an increase of about a quarter over the previous year. Most of the data analysed came from experiments at the N.A.A.S. Experimental Horticulture Stations, while the remainder came from other N.A.A.S. sources.

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THE WEATHER DURING 1958

RECORDS OF THE N.V.R.S. AGRO-MET. STATION

By CHRISTINE DOWN and E. J. WINTER

The distribution of rainfall during 1958 was similar to that of 1957 and 1956 ; a comparatively dry spring was followed by wet conditions during the remainder of the year. Total rainfall in March, April and May was slightly more than two-thirds of the eight-year average for the three-month period. In June, however, rainfall was twice the average amount, and during each of the remaining months rainfall exceeded the average. Because of this, harvesting operations generally were hindered.

The highest Penman soil moisture deficit under a green crop attained during the year was 2.75 inches in May and the deficit fell to 2.3 inches in July. The seven-year average maximum deficit during the year is 4.75 inches, in July, and thus there was little point in irrigating in the open during most of 1958. There was, however, a short period in the early part of the year when watering to assist seed germination and the establishment of transplanted crops might have been beneficial.

In continuation of the work reported previously (1) a permanent pit raingauge was built in which rainfall could be measured at ground level without the risk of in-splash. The help of Mr. Veryard, Mr. Bleasdale and Mr. Hogg, all of the Meteorological Office, in designing this instrument is gratefully acknowledged. Results obtained with this gauge confirm the previous finding that rainfall measured in the standard gauge with its rim 12 inches above short grass is under-estimated.

The weather records for 1958 and the winter of 1957-58 are summarised in the following tables and figure.

TABLE I

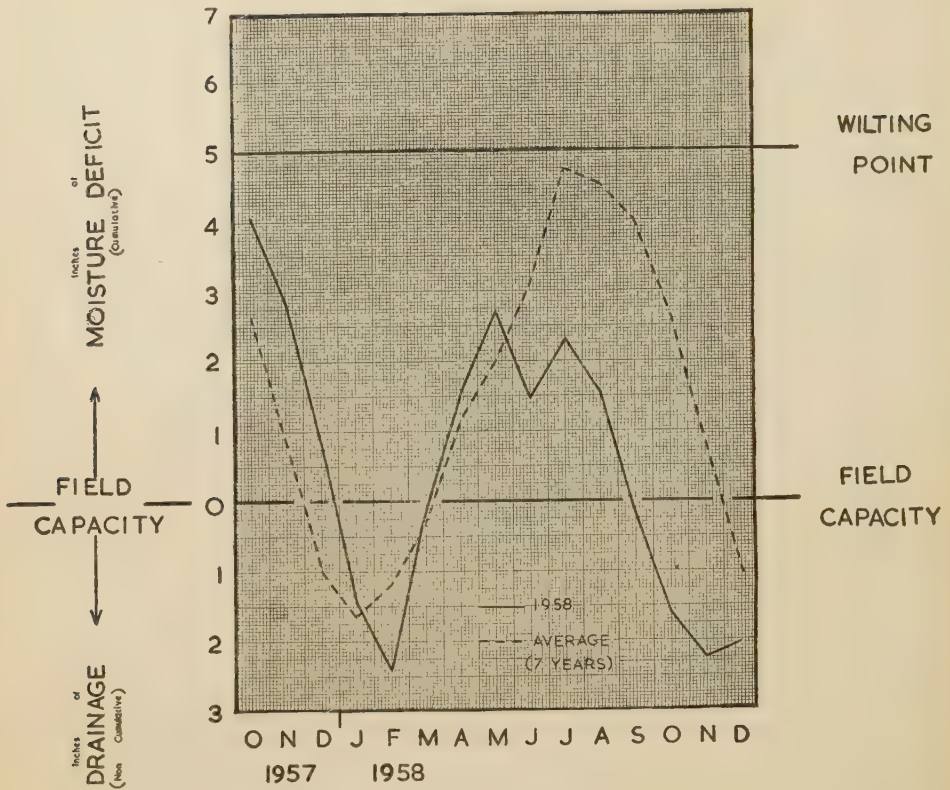
Summary of various weather features during 1958

				*8-year average
Sunshine :	sunniest month	...	May (daily average 6.3 hours)	5.9 hours.
	dullest month	...	December (daily average 0.9 hours)	1.4 hours.
	most in a day	...	13.4 hours on 15th June (80% of possible).	
Rainfall :	wettest month	...	June (4.19 inches)	2.06 inches.
	driest month	...	April (0.47 inches)	1.15 inches.
	most in a day	...	1.14 inches on 2nd June	
	total during 1958	...	29.71 inches	24.68 inches.
Wind :	windiest month	...	February (daily average run—183 miles)	135 miles.
	calmest month	...	November (daily average run—54 miles)	113 miles.
	windiest day	...	11th February (day's run—389 miles)	
	calmest day	...	23rd October (day's run—3 miles)	
	daily average run of wind during 1958—109 miles.			
Air temperature :				
	warmest month	...	61°F. mean temperature in July and August	61°F. (7-year average)
	coldest month	...	37°F. mean temperature in January	38°F. (7-year average)
	highest maximum	...	81°F. on 10th August.	
During winter 1957-58 :				
	lowest minimum	...	16°F. on 24th and 25th January 1958, i.e., 16° of frost.	
	first air frost	...	32°F. on 30th September 1957.	
	last air frost	...	29°F. on 16th April 1958.	
	number of nights with air frost—68			72
	number of nights with ground frost—82			102

*The averages refer to the corresponding month or period during the previous eight years. Thus, in the first entry in the table, the average daily number of hours of sunshine for May during the past eight years was 5.9, but May was not necessarily the sunniest month in every year.

TABLE II
Observations made at N.V.R.S. Agro-Met. Station during 1958

Month	Air temperature °F.		Number of frosts		Mean soil temperature °F. at 0900 hr. G.M.T.			Rainfall		Total solar radiation, gm. calories	Mean daily run of wind, Miles	Evaporation from water surface, Total inches	Evapo-transpiration from grass surface, Total inches
	Mean Max.	Mean Min.	Air	Ground	4"	12"	48"	Total inches	Number of days with rain				
January ...	43	32	13	17	36.2	37.9	41.7	2.51	20	1479	139.72	0.23	0.47
February ...	47	35	11	12	38.5	40.3	42.0	3.06	18	2274	182.77	-0.52	0.70
March ...	45	32	16	19	36.9	38.6	40.9	1.15	11	4924	144.55	0.88	0.85
April ...	53	37	7	11	44.9	44.3	43.7	0.47	6	8161	139.31	1.97	1.87
May ...	62	44	0	2	53.7	53.2	50.5	1.95	17	10825	150.07	3.10	3.16
June ...	66	49	0	0	—	59.7	57.1	4.19	17	10237	89.36	2.49	3.35
July ...	69	53	0	0	63.5	63.7	61.4	2.64	16	11410	104.18	3.81	2.83
August ...	69	52	0	0	61.6	62.5	61.1	3.37	18	9088	100.93	2.80	2.38
September ...	67	52	0	0	59.4	61.2	60.8	3.48	14	—	117.43	2.17	2.23
October ...	57	45	0	2	—	53.4	55.3	2.37	16	3874	96.98	0.86	0.41
November ...	48	38	4	12	—	46.5	49.9	2.42	16	1456	54.00	0.34	0.24
December ...	45	35	8	22	—	41.5	45.1	2.10	23	805	88.26	0.04	0.18
Total 1958 ...	—	—	59	97	—	—	—	29.71	192	—	—	18.17	18.67
8-year average ...	—	—	—	—	—	—	—	24.68	173	—	—	—	—



Theoretical moisture status of a soil completely covered with a green crop.

REFERENCE

- (1) RUBIO, J. I. E., *et al.* (1958). The weather during 1957. *Rep. nat. Veg. Res. Sta. Wellesbourne for 1957, 58.*

LIBRARY REPORT

By BARBARA M. MOORE

Library stock and usage continued to increase steadily during the year. Book accessions numbered 98, a large proportion being basic text and reference books bought with a special grant from the A.R.C. allocated for the purpose. Nine journals were taken for the first time and the subscriptions to three were cancelled. 532 separates were received and 63 volumes of periodicals were bound ; binding can now be considered up-to-date. Holdings are as follows :—

Current periodicals	..	..	..	..	135
Bound periodical volumes	..	..	..	..	767
Books	..	..	..	..	352
Separates	..	..	..	..	2,879

100 reports from other organisations were received in exchange for the N.V.R.S. Annual Report and a geographical reclassification of this material was completed. Loans obtained from other libraries numbered 220. The indexing of separates was resumed and a new system of filing these was introduced under which each item is now given a number on accession and stored in numerical order in filing boxes. New author and subject indexes (U.D.C. as before) have been started and the old indexes will eventually be revised and incorporated into them.

The N.V.R.S. has become a member of ASLIB, a subscription to the Regional Library Bureau has been renewed, and the librarian has joined the International Association of Agricultural Librarians and Documentalists as an individual member.

The library received the valuable gift of an almost complete set of bound volumes of the Journal of Botany, 1863-1941, from the library of the Pharmaceutical Society, Scottish branch, through the mediation of Dr. Alexander Nelson. Other gifts included the Journal of the Royal Horticultural Society, 1938-55, from Warwick County Library and numbers of Science News and New Biology from Dr. A. G. Johnson.

PUBLICATION RECORD

- BLEASDALE, J. K. A. (1957). Smoke pollution and the growth of plants. *Herb. Abstr.*, **27**, 161-5.
(This paper reviews some of the literature on the effects of air polluted with coal smoke on the growth of plants, particularly herbage species. Some of the literature on the effects of sulphur dioxide, a constituent of coal smoke, is also reviewed).
- FAULKNER, G. J. and JOHNSON, A. G. (1958). The best spacing for quick-freeze sprouts. *Grower*, **49**, 617.
- JOHNSON, A. G. (1958). Brussels sprout breeding at N.V.R.S. *Evesham Standard, Hort. Supplement*, 25th April.
- JOHNSON, A. G. (1958). Progeny testing. How to increase top-quality yields. *Grower*, **50**, 868.
- JOHNSON, A. G. (1958). Male sterility in *Brassica*. *Nature, Lond.*, **182**, 1523.
(A description of the form and inheritance of male sterility found in breeding material of Brussels sprouts).
- ROBERTS, H. A. (1958). A review of the use of herbicides in British vegetable production. *Emp. J. exp. Agric.*, **26**, 283-92.
(This article reviews the British literature on herbicides for use in vegetable crops and discusses the chemical control methods currently practised).
- ROBERTS, H. A. (1958). Herbicides in horticulture. *Agric. Rev., Lond.*, **3**, (9), 34-7.
- ROBERTS, H. A. (1958). Studies on the weeds of vegetable crops. I. Initial effects of cropping on the weed seeds in the soil. *J. Ecol.*, **46**, 759-68.
(The populations of viable weed seeds in the soil of long-term manurial and cultivation experiments at Wellesbourne were assessed by means of a sampling technique. During the first and second years of vegetable cropping the average numbers in the top 6 inches were reduced to 38 and 19 per cent, respectively of the original high level of 229 millions per acre. The behaviour of the different species is discussed and the results compared with those of other workers).
- SALTER, P. J. (1957). Blindness in early summer cauliflower. *Nature, Lond.*, **180**, 1056.
(Plants of the variety Finney's 110 were subjected to a period of low temperature when approximately seven leaves had been initiated which resulted in 60 per cent of the plants becoming blind. Low temperature treatment before or after that stage of development caused blindness to a lesser extent).
- STANHILL, G. (1958). Effects of soil moisture on the yield and quality of early turnips. *J. hort. Sci.*, **33**, 108-18.
(Turnip plants at eight different stages of growth were subjected to a three-week period of either daily or no irrigation. The different responses in yield resulting from the period of wet-treatment at the various ages could be related to three distinct phases of growth of the plants. During the last of these phases the treatments had their greatest effect on yield).
- STANHILL, G. (1958). Rainfall measurements at ground level. *Weather*, **13**, 33-4.
(Daily measurements of rainfall made with a standard gauge having its rim 12 inches above short grass were found to be less than those made with a similar gauge whose rim was at ground level, precautions having been taken to prevent insplash. The differences were found to be correlated with the daily run of wind. It is suggested that a ground level gauge or a ground level evaporation tank may give a better measure of true rainfall than the standard gauge).

- STANHILL, G. (1958). An irrigation gauge for commercial use in field and glass-house practice. *J. agric. Engng Res.* **3**, 292-8.
(An instrument is described which gives a direct indication of the soil moisture deficit under field crops and, in a modified form, under glasshouse crops. Theoretical limitations and practical difficulties which may arise when using this kind of instrument to regulate commercial irrigation are discussed).
- STANHILL, G. (1958). *J. Instn Wat. Engrs*, **12**, 377-83.
(At Wellesbourne there was close agreement between measured evaporation from an open water surface and that estimated by Penman's formula. Potential evapo-transpiration from grass was 85 per cent of the measured or estimated evapo-transpiration. Thornthwaite's method tended to give over-estimates of water loss. Measured solar radiation at Wellesbourne was highly correlated with potential evapo-transpiration. The water loss from daily-irrigated grass was not markedly greater than that from grass growing under natural rainfall until more than half of the available soil water had been depleted. Under average English conditions actual evapo-transpiration was estimated to be within 10 per cent of the potential water loss).
- TOMLINSON, J. A. and SMITH, B. R. (1958). Big vein disease of lettuce in Great Britain. *Plant Pathology*, **7**, 19-22.
- TOMLINSON, J. A. and WEBB, M. J. W. (1958). Control of turnip and cabbage mildew (*Erysiphe polygoni* DC) by zinc. *Nature, Lond.*, **181**, 1352-3.
(Turnip and cabbage plants, when grown in soil containing zinc-fritted glass or zinc sulphate, became resistant to *Erysiphe polygoni* DC. Cucumbers, chrysanthemums and gooseberries remained susceptible to their powdery mildew diseases when similarly treated. Analysis showed that zinc had accumulated in the leaves of zinc-treated plants).
- WATTS, L. E. (1958). Natural cross-pollination in lettuce, *Lactuca sativa* L. *Nature, Lond.*, **181**, 1084.
(Observations on the progeny of lettuce which had been allowed to flower in the field, indicated that the amount of cross-pollination increased towards the end of the flowering season. This rise was attributed largely to the seasonal increase in the hover-fly population).
- WATTS, L. E. and GEORGE, R. A. T. (1958). Classification and performance of varieties of radish. *Rep. nat. Veg. Res. Sta. Wellesbourne for 1957*, 15-27.
(114 commercial varieties of radish have been classified according to root and leaf characters, and other data are given on performance).
- WINTER, E. J. (1957). Masters Memorial Lecture, 1957. The watering of field and glasshouse crops in the United Kingdom. *J. R. hort. Soc.*, **82**, 476-83 ; **83**, 6-15.
(A general account is given of the principles underlying modern irrigation practice, and of experiments on the water requirements of vegetable crops. Devices for indicating the current field soil moisture deficit and for automatically controlling a glasshouse irrigation system according to the needs of the plants, are described).
- WINTER, E. J. (1958). Field crop irrigation. Pointers from the recent Wellesbourne research. *Comm. Grower*, No. **3245**, 609-13.
- WINTER, E. J. (1958). Some aspects of the irrigation of vegetables. *World Crops*, **10**, 217-20.
- WRIGHT, D. W. (1958). A combined treatment for the control of cabbage root fly and whiptail in summer cauliflowers. *Rep. nat. Veg. Res. Sta. Wellesbourne for 1957*, 46-7.
(A treatment is described for the control of both cabbage root fly and whiptail in cauliflowers using dieldrin and sodium molybdate applied to the soil shortly before or after transplanting).

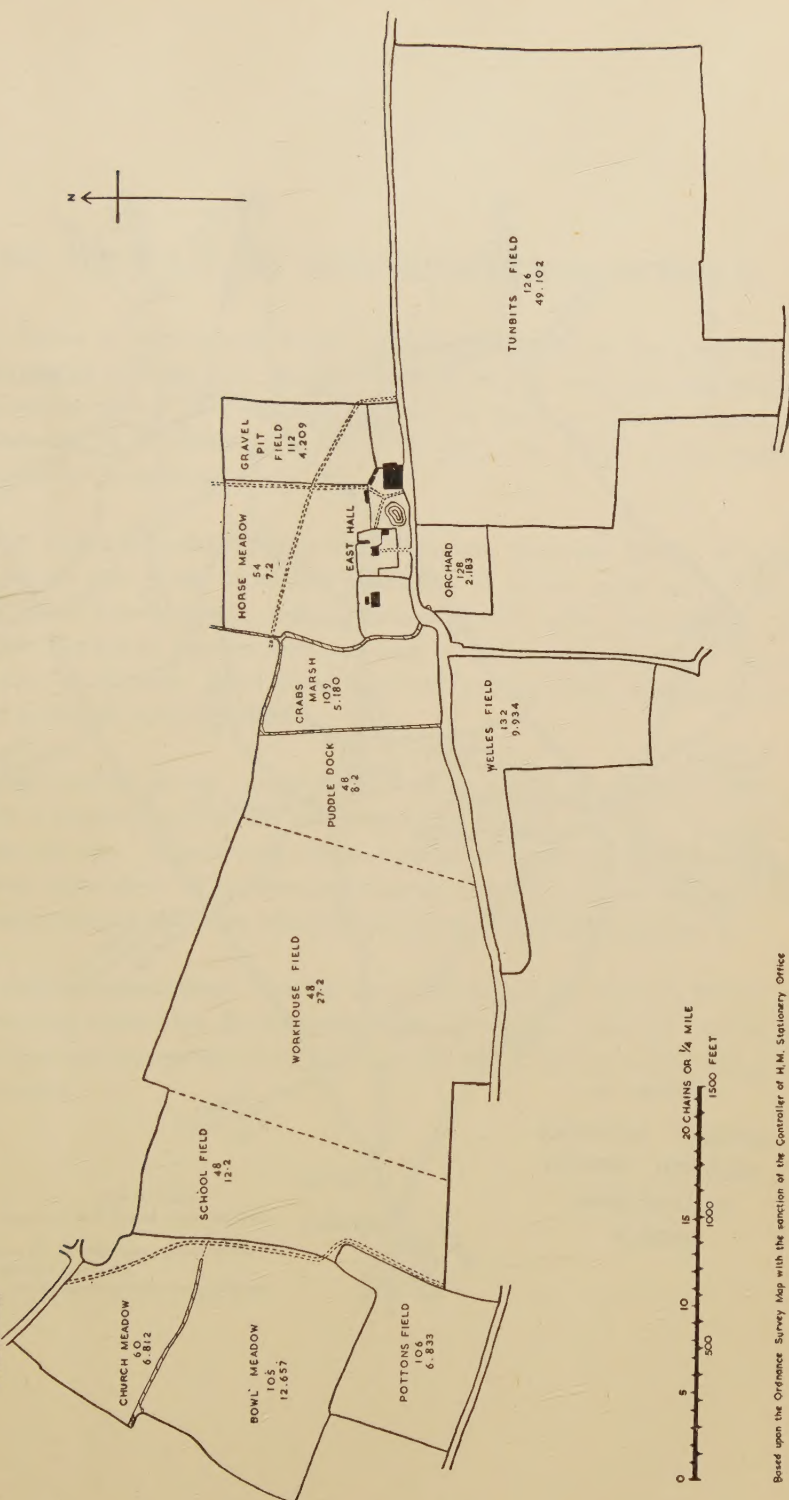
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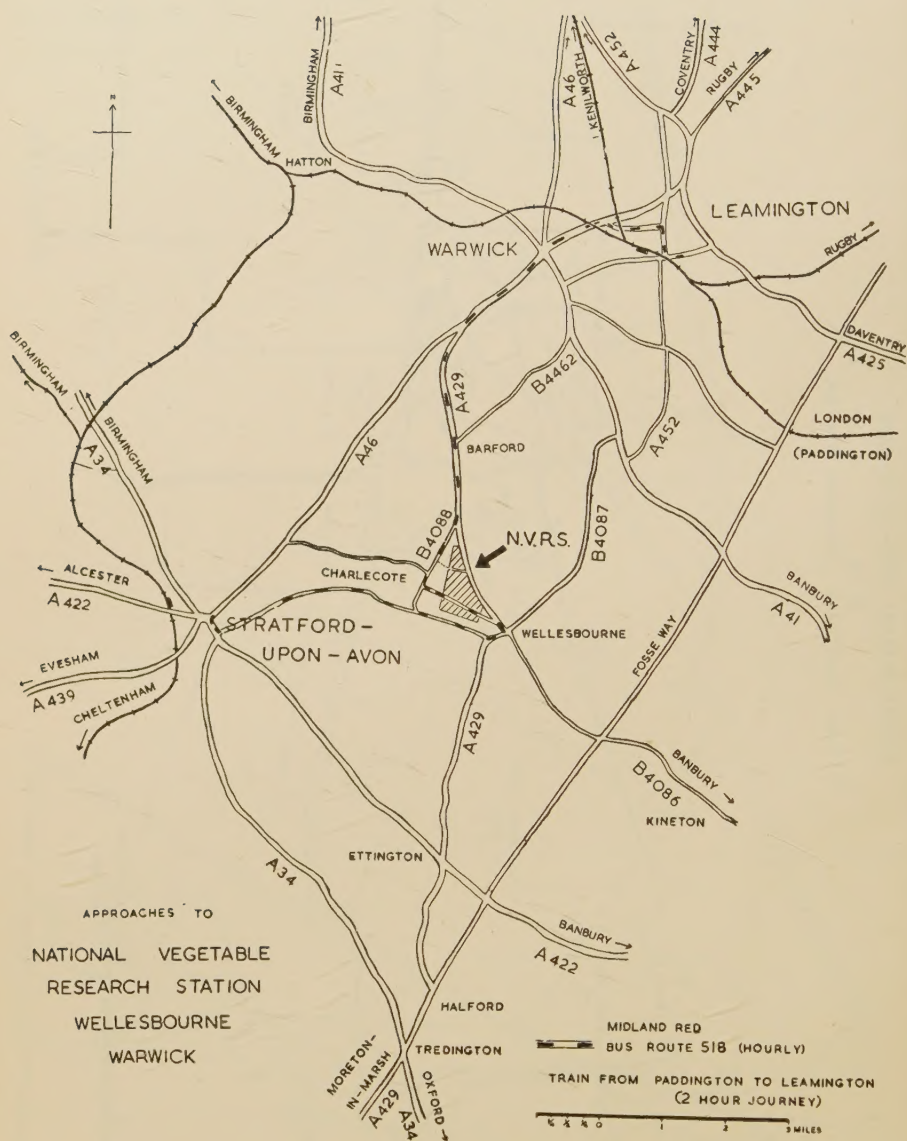
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THE JOURNAL OF HORTICULTURAL SCIENCE

The Journal of Horticultural Science, which is sponsored by the Long Ashton Research Station and the East Malling Research Station, welcomes contributions on horticultural science from Research Institutes at home or abroad. Papers for publication and all communications should be sent to the Editor at East Malling Research Station, Maidstone, Kent.

Recent papers describe work on fruit, vegetables, hops and flowers, including cultural studies ; the effects of mineral deficiencies in various crops such as apple, broccoli, cacao, lettuce, potato, tomato, strawberry and bulbs ; fruit storage ; the biology and control of pests of fruit and their predators ; the control of fungous diseases and virus diseases ; genetical studies of fruits and vegetables ; soil sterilisation ; and weed control in vegetable crops.

Already received for the current Volume 34 are papers describing research on the effects of irrigation on summer cauliflower, and of weed growth on the yield of onions and red beet. There are also detailed studies of the growth of leaves and fruit of tomatoes under glass. Virus diseases of certain fruits, flowers and hops are dealt with in several papers describing pathological aspects of horticultural crops.

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